THE ROYAL SOCIETY OF TASMANIA

THE ADVANCEMENT OF KNOWLEDGE

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Cover Image: Adult female thylacine being prepared as a mounted specimen and positioned to reveal a severe injury just below the jawbone (from Medlock's paper, image © 2025 Australian Museum).

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

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VALE DISTINGUISHED PROFESSOR JAMES BARRIE KIRKPATRICK AM (1946–2024)

It is with great sadness that the Royal Society of Tasmania acknowledges the passing of Distinguished Professor James (Jamie) Kirkpatrick AM on 21 October 2024, as one of the Society's most prestigious long-standing members. It is especially appropriate to publish this tribute in the *Papers and Proceedings of the Royal Society of Tasmania* because Distinguished Professor Kirkpatrick has been the most prolific author in the journal's history, and with publications spanning over 50 years, holds a record unlikely to be equalled.

Known for so many aspects of geography, planning and spatial sciences, Professor Kirkpatrick's dedication to his profession was driven by his passion and overwhelming commitment to protect Tasmania's natural ecosystems, about which he cared so deeply. This tribute, collated from many sources, recognises the magnitude and legacy of his defining academic career at the University of Tasmania and strives to capture the measure of Jamie as a person.

James Barrie Kirkpatrick was born in Melbourne on 12 October 1946. He was raised and educated in Victoria and completed his higher degrees at the University of Melbourne. In 1968 he completed his Bachelor of Arts with Honours and in 1973 gained his Doctor of Philosophy with his thesis titled *Geographic Variation in* Eucalyptus globulus *Labill: Including Studies on the Distribution and Taxonomy of the Species*. After working for some time as a tutor, and prior to completing his PhD, Jamie accepted a lectureship position at the University of Tasmania. In 1972, he started in the Department of Geography at the UTas campus, Sandy Bay, where he remained his entire career, serving as Head of various academic units in what is now the School of Geography, Planning and Spatial Sciences. His skills were highly regarded and by 1981 Jamie was appointed Senior Lecturer and in 1988 appointed Professor.

Throughout his career the breadth of his research and teaching roles extended to a hugely diverse range of flora and fauna species, communities, ecosystems, landscapes, policy and legislation, world heritage, wilderness, reserve design, habitat loss, urbanisation, climate change, invasive pests, roadkill and so much more. In 2024 Jamie's UTas staff profile formally lists his expertise in the fields of: ecology, pedology, bio-geomorphology, climatology, political geography, social geography and cultural geography related to nature conservation.

Professor Kirkpatrick was recognised internationally for his pioneering work on reservation planning methods, but his research loves were alpine, alkaline, grassy woodlands and coastal ecosystems where he remained a field-based ecologist. In 1997 Jamie was awarded the National Eureka Prize for Environmental Research. The citation reads:

> *For his outstanding contribution to knowledge of Tasmanian vegetation and conservation policies and strategies, through 25 years of research, survey and analysis on the ecology of endangered species and ecosystems. For energy, intellect and integrity.*

In addition to lecturing to undergraduates, Jamie became the life-changing mentor and supervisor of so many postgraduates privileged to work with him. At any one time he could have up to ten postgraduate research projects under his wing. His UTas colleague Professor Elaine Stratford said:

PLATE 1 — Distinguished Professor Kirkpatrick AM in March 2021 receiving the Royal Society of Tasmania's Clive Lord Medal from then-Governor Her Excellency the Honourable Kate Warner AC.

> *… many of Jamie's former students are now professorial staff in other universities here and around the world; working for very prestigious international environmental governance organisations, across the Commonwealth and several state and local governments, in private sector organisations – often as the resident voice for the more-than-human, for non-government organisations, and sometimes for themselves in successful consulting operations.*
> (https://www.iag.org.au/jamie-kirkpatrick--distinguished-fellowship-).

As the magnitude and significance of Jamie's research grew, in 2003, he was made a Member of the Order of Australia for 'service to environmental conservation,

PLATE 2 — Three of Jamie's books published during his long and distinguished career (*A Continent Transformed* (second edition 1995), *In the Forest* (2001), *Conservation Worrier* (2017)).

particularly in relation to World Heritage assessment and the development of forest reservation criteria'. In 2006, he was awarded a Doctor of Science by UTas 'for a substantial and sustained contribution to scientific knowledge over a long career', and in 2009 he was appointed a Distinguished Professor of Geography, Planning and Spatial Sciences. In the same year he was awarded a Distinguished Fellowship of the Institute of Australian Geographers, and in 2015 received the JP Thomson Medal from the Royal Geographical Society of Queensland.

In its tribute to Jamie, the Ecological Society of Australia, representing the premier group of ecologists, said:

> *…he was a pioneer in ecology and geography, dedicating his life's work to understanding and protecting our environment and was a major player in adding to Tasmania's reserved estate, including securing the 1990 Tasmanian Wilderness World Heritage Area boundaries and later extensions. His iterative reserve design methodology and his long-held belief that 30% was a minimum target for protection will be an important global legacy.*
> (https://www.ecolsoc.org.au/obituaries/vale-distinguished-professor-james-kirkpatrick-am/)

In 2019 Distinguished Professor Kirkpatrick AM was awarded the Clive Lord Medal by the Royal Society of Tasmania in recognition of his research into Tasmania's natural environment, including conservation planning, forest conservation and world heritage assessment. He was presented with the medal at a prestigious ceremony at Government House on 16 March 2021 by then-Governor Her Excellency the Honourable Kate Warner AC (pl. 1). Due to Covid restrictions, Jamie delivered his Clive Lord Lecture, *Cyclic Dynamics in Tasmanian High Mountain Treeless Vegetation*, online and the lecture was later posted on the RST YouTube channel.

Jamie's research was first published in the journal *Papers and Proceedings of the Royal Society of Tasmania* in 1973 with a paper on the natural history of Curtis Island, Bass Strait. This paper began a publishing tradition he maintained almost annually for 51 years culminating in 57 authored and co-authored papers, making him the Society's most productive academic contributor. His final paper, *Predicting Spatial Variation in the Upper Limit of Trees on the Alpine Mountains of lutruwita/Tasmania*, was published in Volume 158 in December 2024. While it is customary to publish a full account of a distinguished scientist's academic works, the magnitude of Jamie's research output is staggering. It numbers over 520 scientific papers, reports, chapters and books; equating to ten publications per year for 50 years and a testament to his work ethic. A comprehensive list of Jamie's publications can be found on the following sites, though more are being added as his collaborators acknowledge his input:

- https://discover.utas.edu.au/J.Kirkpatrick/publications
- https://scholar.google.com.au/citations?user=Fu6TmL4AAAAJ&hl=en&oi=sra

Jamie served on numerous high-profile boards, councils and committees across every tier of government. These included the Environmental Protection Advisory Council of Tasmania, various other state and national heritage, national estate and environmental bodies. He was Chair of the

Australian Heads of Geography Departments Committee, Chair of the Worldwide Fund for Nature Scientific Advisory Council, President of the Ecological Society of Australia and President of Australian Geographers. Noteworthy among these positions was his long tenure on Tasmania's statutory National Park and Wildlife Advisory Committee providing advice to the Tasmanian and Australian governments on management plans, policies and matters relating to the protection and conservation of the reserve estate, including the Tasmanian Wilderness World Heritage Area. He contributed to these bodies with candour and respect, always giving professional advice.

I was fortunate to serve on several committees with Jamie including six years on the Ministerially Appointed Scientific Advisory Committee deliberating on nominations under Tasmania's *Threatened Species Protection Act 1995*. Not only did Jamie contribute to the listing of a significant number of threatened flora and fauna species but he dealt with politically charged nominations such as blue-finned tuna and giant kelp. I later served with Jamie on the Tasmanian Land Conservancy's Science Committee to help direct science programs and develop a world-class reserve matrix for prioritising private land protection. Jamie was a life-long supporter of the Tasmanian Land Conservancy and helped spearhead several private reserve campaigns.

In addition to these demands, Jamie also found time to support many other environmental organisations such as the Tasmanian Conservation Trust, the Tasmanian Environment Centre and the Wilderness Society. He never shied from giving fearless advice or supporting protest campaigns. The Bob Brown Foundation described Jamie as 'Tasmania's towering figure of the natural sciences', and former Greens Leader Christine Milne stated he was 'The geographer and conservation ecologist who has been our anchor in academia and fellow activist on the front line of nature conservation in Tasmania for the past half-century' (https://bobbrown.org.au/bbf-mourns-death-of-jamie-kirkpatrick/).

But scientific research papers weren't his only focus. Jamie constantly explored the human condition and our complicated relationship with nature. He joined with revered wilderness photographer Peter Dombrovskis and author Richard Flanagan to produce *On the Mountain* (1996), and featured Dombrovskis sublime photographs for *In the Forest* (2001) (pl. 2). Jamie self-published a remarkable range of introspective and personalised nature and satirical books under his own label 'De Press Inc'. In *Ecology Underfoot* (2024) he wrote:

> *…In the many landscapes lacking grandeur in the ancient worn-down continent of Australia, there are places where the fabric of life, soil and rock at my feet … have produced a jolt of aesthetic pleasure mixed with the esoteric delights of scientific curiosity.*

One reviewer of his irreverent memoir *Conservation Worrier* (2017) stated 'First he gave us the hilarious and apposite Tasmanian Development Calendar, and now he's back with *Conservation Worrier* … a rollicking, cheeky memoir high on humour and low in didacticism'. In keeping with Jamie's final wishes, the *Tasmanian Geographic* has made available seven of Jamie's books, new and old, for free download (https://tasmaniangeographic.com/presents/kirkpatrick/).

Jamie's last three books were launched at a special event held on the Queens Domain, Hobart, on 12 October 2024 to coincide with his 78th birthday. Jamie loved the Domain and conducted numerous conservation assessments and long-term research projects there to guide the Hobart City Council's management of the area. During the launch, attended by over 150 colleagues, former students and friends, many spoke of their academic admiration and love of his energy, enthusiasm and good humour. Jamie responded with his trademark wit and laughter, touching all who were privileged to be there.

Jamie was one of a kind. A revered, respected scientist and a friend who always gave so generously and selflessly. Jamie's legacy will live on in his landmark publications, the students he mentored across the ages and the enormous network of friends and colleagues who stand in awe and admiration of his contribution to nature conservation in Tasmania and beyond.

Dr Sally Bryant AM
Honorary Editor

TOWARDS AN UNDERSTANDING OF WIND DISPERSAL OF *ACACIA* POLLEN IN SOUTHEAST TASMANIA

by Anthony Roderick Griffin, Jane L Harbard and Penelope Jones

(with two figures, three tables and two appendices)

Griffin, AR, Harbard, JL & Jones, P (2025). Towards an understanding of wind dispersal of *Acacia* pollen in southeast Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 159: 5-15. ISSN 0080-4703. School of Natural Sciences, University of Tasmania, Private Bag 78, Hobart, Tasmania 7001, Australia (ARG*, JLH). Menzies Institute for Medical Research, University of Tasmania, Level 3, 17 Liverpool Street, Hobart, Tasmania 7000, Australia (PJ). *Author for correspondence. Email: rodgriffin@iinet.net.au

Since 2015, daily atmospheric pollen samples have been collected on the University of Tasmania campus in Sandy Bay, Hobart, and classified according to botanical origin. We used this database to relate temporal variation in daily catch of *Acacia* pollen to both the flowering phenology of 16 species growing within 300 m of the sample point and to ambient weather conditions. Flowering was observed between July and December 2023. Only *A. baileyana* was flowering in early July and only *A. mearnsii* in December. Peak flowering of most other species co-occurred in August/September and pollen source could not be differentiated. Repeatability of the seasonal flowering pattern is demonstrated for 2016–2023. During the peak 2023 flowering season pollen catch was highest during periods of relatively warmer and windier weather, with wind speed at 3 pm on the day prior to the 9 am sample collection significantly associated with pollen count. Results are consistent with the proposition that, in addition to insects, wind may play a role as a pollen vector and that ambophily may be a more correct description of the pollination syndrome for these SE Australian *Acacias*.

Key Words: *Acacia*, flowering phenology, wind pollination, pollen dispersal, pollination syndrome, ambophily.

INTRODUCTION

Most species of *Acacia* exhibit an outcrossing breeding system, requiring transfer of pollen between different plants for successful seed set (Gibson *et al.* 2011). Published reviews of *Acacia* pollination ecology (Bernhardt 1989, Stone *et al.* 2003) focus strongly on the role of a diversity of insects as pollen vectors. However, over 80% of *Acacia* species native to SE Australia, flower in late winter to early spring (Costermans 2009), when there are relatively few insect visitors that are large and/or active enough to be efficient pollen vectors (Griffin *et al.* 2020). There is an increasing realisation that many plant species are best described as ambophilous, that is, exhibiting both biotic and abiotic pollen dispersal (Culley *et al.* 2002). This possibly includes some Australian Acacias (Giovannetti *et al.* 2018, Wandrag *et al.* 2023).

It is well established that some *Acacia* pollen can be dispersed by wind. For example, Smart and Knox (1979) reported airborne pollen in springtime Melbourne and the genus is also considered a potential allergen (Allergy & Autoimmune Disease 2022). In SE Tasmania, Tng *et al.* (2010) listed *Acacia* as the sixteenth most prevalent taxon in the pollen cloud sampled in Hobart over a calendar year, and cited comparable data from Sydney, Brisbane and Darwin. The unresolved issue is the extent to which such dispersion contributes to effective cross-pollination of different species of *Acacia*.

Since 2015, the AirRater program, conducted by the Menzies Institute in Hobart (Johnston *et al.* 2018) has collected daily records of airborne pollen from a rooftop on the University of Tasmania (UTas) Sandy Bay campus, to aid understanding of the medical impacts of variation in air quality. Twenty-seven distinct pollen taxa are classified to at least Family level, and, because of its distinctive polyad structure (Kendrick & Knox 1982), it is easy to observe and count pollen of genus *Acacia*.

In addition to its main health objective, the AirRater database also provides a unique opportunity for the study of diurnal and seasonal variation in dispersion of the pollen of each recorded plant taxon. The current study would have been impracticable without such access.

In 2023, we recorded the flowering phenology of 16 native and ornamental species of *Acacia* growing on the UTas Sandy Bay campus and, with reference to the AirRater database, related this to daily pollen catch. Using meteorological data from a nearby Bureau of Meteorology station, we also explored the relationship to weather conditions. For comparison with the pollen dispersion pattern of a specialised wind-pollinated species we also present data for *Pinus radiata* which flowers concurrently. Repeatability of the seasonal variation in the catch of *Acacia* pollen, and by inference species' phenology, was demonstrated through comparison of data for the eight years from 2016 to 2023.

METHODOLOGY

Local *Acacia* population

There are 21 native and seven naturalised species of *Acacia* in Tasmania (Jordan 2024). Additional species from the mainland are commonly planted as ornamentals. We recorded the flowering phenology of all individuals of the

16 species (six native to SE Tasmania and 10 introduced from elsewhere in the State or from mainland Australia), which are either planted or naturally occurring on campus within 300 m of the trap site (table 1). These species are taxonomically diverse, representing four different sections of the genus (Murphy & Maslin 2023). We are confident that all potential pollen donor species in the region were included in the survey.

Pinus radiata also flowers during August/September (Hetherington, S pers. comm.) and pollen catch data are presented for comparison with the *Acacia* results. There are no pine trees on campus, the nearest individual being 640 m to the NW; however, there are substantial commercial plantations in the region, the nearest being at Moogara 30 km to the NW of campus. Smaller plantings occur closer to Hobart on farms and parkland.

Flowering phenology

We observed all 228 *Acacia* plants within a 300 m radius of the trap location (appendix 1). This area represented a compromise between observational workload and need to demonstrate that the pollen was indeed capable of wind transport over significant distances. We divided the study area into 22 'locations' of varying sizes reflecting the patchy distribution of plants and recorded the number of individuals of each species at each location. Then, at approximately two-week intervals from the end of June 2023 (the first flowering of *A. baileyana*) to the conclusion of the flowering of *A. mearnsii* in December, we assessed the phenological state of groups of individuals within species within locations. From observations in earlier years, we knew that this period would cover the flowering of all species except *A. uncifolia*, a medium-sized shrub which was represented by five plants within an average of 60 m of the sample point (table 1).

All species except *A.uncifolia* have a single discrete flowering season of varying length, enabling phenology assessment by the scoring method described for trees in a nearby natural population of *A. dealbata* (Griffin *et al.* 2020). Where there was only one plant per species per location the percentage of open flowers was visually estimated on a decile scale from very few (<+10 %), to full flowering (100%) and then decreasing in negative deciles to -10%. With more than one plant of a species at a location the range of states from most to least advanced was noted and the modal value estimated. All records were collected by one observer. Although we scored all species, we only present analysis of the phenology data from the ten species with seven or more individual plants. These include the three natives of tree-form (*A. dealbata, A. melanoxylon* and *A. mearnsii)*. For the remaining species with small

TABLE 1 — *Acacia* species present on the University of Tasmania Sandy Bay campus and included in the 2023 phenology study

Species	Section (after Murphy & Maslin 2023)	Habit	Total no.	Mean distance (m) to pollen trap	Distance to nearest plant (m)	Status in region[1]
A. dealbata	Botrycephalae	tree	28	155	65	native
A. mearnsii	Botrycephalae	tree	60	170	35	native
A. baileyana	Botrycephalae	large shrub	15	255	185	introduced ex NSW
A. melanoxylon	Plurinerves	tree	15	80	35	native
A. boormanii	Acacia[2]	small shrub	24	115	65	introduced ex NSW/Vic
A. cultriformis	Acacia[2]	small shrub	2	100	100	introduced ex NSW/Qld
A. fimbriata	Acacia[2]	small shrub	2	210	185	introduced ex NSW/Qld
A. howittii	Acacia[2]	large shrub	30	210	35	introduced ex Vic
A. pravissima	Acacia[2]	large shrub	21	170	35	introduced ex NSW/Vic
A. pycnantha	Acacia[2]	small shrub	1	100	100	introduced ex SA/Vic
A. stricta	Acacia[2]	small shrub	2	240	240	native
A. uncifolia	Acacia[2]	large shrub	5	60	35	native to Tas but not SE region
A. floribunda	Juliflorae	small shrub	8	150	150	introduced ex NSW/Qld
A. longifolia	Juliflorae	large shrub	7	160	100	introduced ex NSW/Vic
A. mucronata	Juliflorae	small shrub	1	35	35	native
A. verticillata	Juliflorae	small shrub	7	100	100	native
			228			

[1] distribution information ex *Flora of Australia*

[2] syn. Sec. Phyllodineae

observable populations, we simply tabulate the first and last dates on which open flowers were observed on one or more plants (app. 2). Distance from each location to the pollen trap was recorded and used to calculate a weighted mean distance for the population of each species (table 1), as a basis for qualitative discussion of the probability of being a source for trapped pollen.

Pollen capture

Pollen data were collected by the AirRater pollen monitor located on the roof of the UTas Life Sciences building, Sandy Bay, Hobart, approximately 11 m above ground level (app. 1). The pollen monitor is a standard Burkard volumetric sampler (Burkard Manufacturing Co. Ltd, Hertfordshire), fitted with a 24-hour head. Pollen samples were collected in accordance with the Australian Pollen and Spore Monitoring Interim Standard and Protocols (Beggs *et al.* 2018). The monitor draws in air at a rate of 10 L/minute through a narrow (2 x 14 mm) inlet. Pollen and other particles in the air are impacted onto a slide coated with Syglard adhesive. The slide moves slowly through the 24-hour sampling period, and pollen is distributed across its surface. The slides are collected and replaced daily at 9 am. After sample collection, three transects of pollen are counted at 400x magnification. The resulting pollen counts are ordinarily converted to atmospheric concentrations (grains/m^3) using the formula provided in Beggs *et al.* 2018. With the standardised assessment protocol, a conversion factor of 0.6481722 is applied, so a catch of 10 polyads equates to 6.48 polyads/m^3 over the 24-hour sampling period. However, for this study where relativities of daily, cumulative weekly, and monthly catches were of primary interest we chose to analyse raw 24-hour count data.

The distinctive polyad structure makes it easy to identify *Acacia* to generic, but not species, level so we are only able to infer likely source taxa from the phenological data and location of plants in relation to the trap.

Historical pollen records

Daily pollen samples have been collected continuously since October 2015. To assess yearly repeatability of the seasonal pattern of *Acacia* pollen catch we calculated the monthly total number of polyads captured for each year from 2016 to 2023 and present these in bar chart form.

Meteorological data

For the peak flowering months of August and September we accessed daily weather records from the Bureau of Meteorology station at Edgerly Rd, Hobart (Bom.gov.au. 2023). This is located 1.8 km to the north of the campus at a comparable elevation. We analysed the following variables: maximum daily temperature; rainfall; RH% at 3 pm; maximum wind gust; and wind speed and direction at 3 pm. It is important to note that these are 24-hour records midnight to midnight, whereas the daily pollen records are from 9 am to 9 am. It was therefore considered most informative to focus on weather for the day prior to each pollen count.

ANALYSIS

Phenology records

For each observation date, data for each species were pooled over locations and the modal stage of flowering of the total population plotted over time to represent the seasonal progression in phenology. For ease of graphical representation, stages were pooled into six classes and plotted on the same x-axis as the pollen catch data. For weeks that were not monitored we assumed an intermediate state between the two nearest observations.

Pollen data

The pollen count database was used in two ways. For demonstration of the seasonal variation in pollen catch and its relationship to phenology, we summed the daily pollen catch for each week from July–December and graphically aligned these totals with the plots of the phenological state of each species. When exploring relationships to meteorological conditions, we used individual daily records.

Meteorological data

During the months of August and September there were 18 days when zero *Acacia* pollen was recorded (designated as Set 1), and 10 days with a catch of 5 or more polyads (average 8.1) (Set 2). We used double ended t-tests to determine whether there was a significant difference between Sets for each weather parameter, and in the respective catches of pine pollen which were included to indicate the extent to which the weather effect is generalisable to other plant taxa. We used a Chi-squared test to assess the significance of variation in wind direction between Sets, based on the respective counts of the days from the SSW-N sector compared to NNE-S.

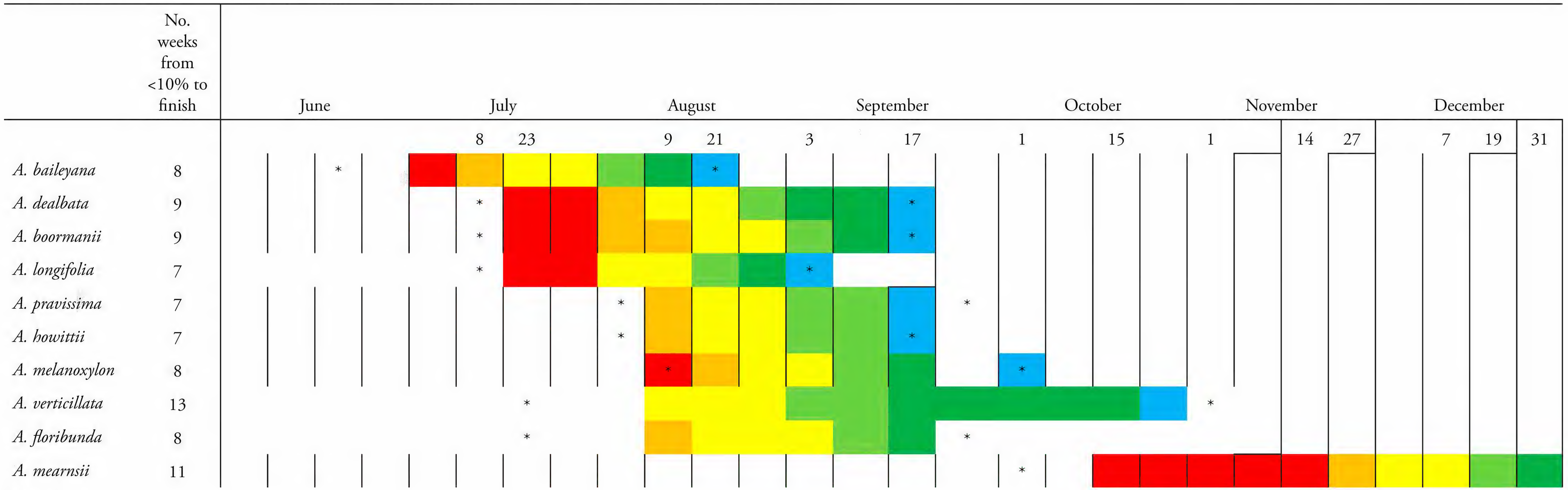
As a second approach, we identified the week with highest *Acacia* pollen catch in each of the months of July, August and September, and then compared prevailing weather conditions with the respective monthly mean values for each parameter.

RESULTS

Flowering phenology

Observation commenced at the beginning of July 2023 and continued to the end of December. The progression of flowering of each of the 10 species with a population size of seven or more (table 1) is shown in figure 1. Until the third week in July, only *A. baileyana* was in flower, finishing in mid-August. During mid-August to mid-September eight of the species flowered concurrently, with six at around peak flowering in the third week of August. These include

FIGURE 1 — Flowering phenology of 10 *Acacia* species with 7 or more individuals, aligned with weekly pollen catch. Observation dates are indicated. For weeks with no observations the most likely stages are interpolated. Catch of *Pinus* pollen over the same period is included for comparison.



No. *Acacia* polyads trapped	1	0	2	1	1	3	0	18	13	14	26	12	10	25	13	4	2	1	3	0	2	10	7	3	13	1	2	1
Pinus pollen grains trapped	0	1	0	0	0	6	14	103	136	108	182	48	99	304	183	173	23	9	12	5	2	0	5	1	0	0	0	0
Total pollen	117	175	850	360	872	449	646	691	586	396	708	402	836	2069	847	1512	726	397	346	692	261	593	463	367	598	450	472	759

very few < 10% open

20%<50% open

60%<100% (peak flowering)

peak down to 60% open

50% > 10% still open

finished

* earliest and latest individual plants at 10%

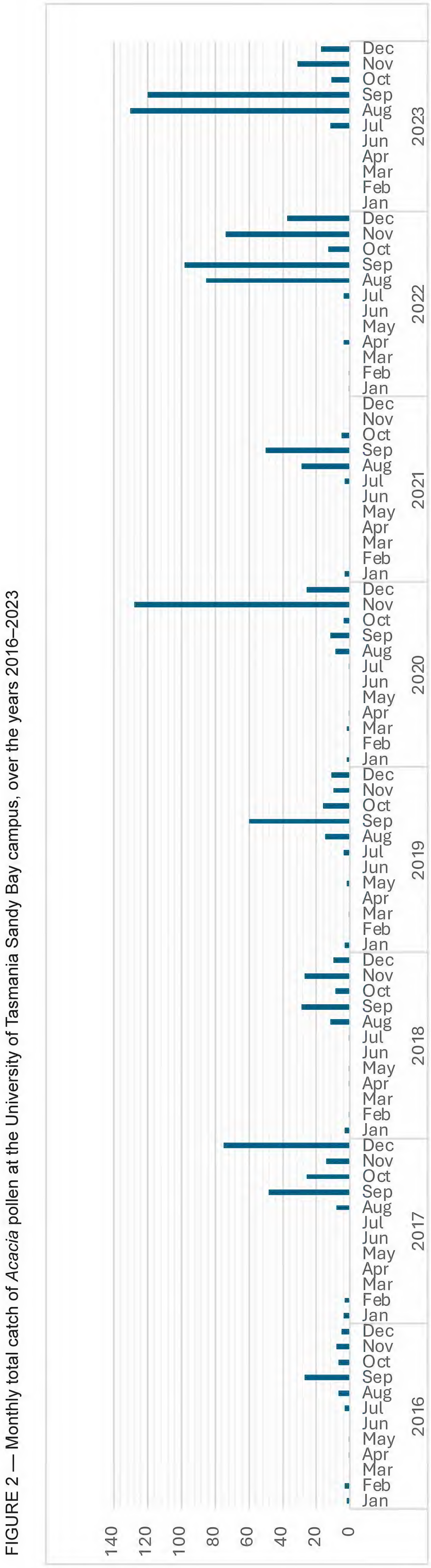


FIGURE 2 — Monthly total catch of *Acacia* pollen at the University of Tasmania Sandy Bay campus, over the years 2016–2023

representatives of all four taxonomic sections of the genus in the study (table 1). From late September through October, only two species (*A. melanoxylon* and *A. verticillata)* were in the later stages of flowering, with a few flowers opening on *A.mearnsii* from mid-October. Flowering of the latter species peaked in early December and was complete by the end of that month. The total flowering period of individual species ranged from seven (*A. longifolia*, *A. pravissima* and *A. howittii*) to 13 weeks (*A. verticillata*). In each species there were individual plants which produced a few flowers earlier or later than indicated by these ranges.

Repeatability of flowering patterns as inferred from the pollen records 2016–2023

The bimodal pattern observed in 2023 was also broadly evident in earlier years (fig. 2). Where this was less evident (in 2016, 2019, 2021) there was little or no pollen in November–December, presumably because of poor flowering in *A. mearnsii.* This is the only common species flowering in the region at that time and the most prevalent on campus with 60 trees including several within 35 m of the trap (table 1). Except in 2017 and 2022, when there was a particularly high November/December catch, most pollen was trapped in August–September, with temporal repeatability indicated by August being higher than July in all eight years, and September likewise always higher than October. Every year apart from 2021 there was also a small amount of pollen trapped during the period February–April. This is most likely from *A. uncifolia* which was the only species still in flower in March 2024 (Griffin unpubl. data) and capable of flowering throughout the year (Lynch 1994). In seven of the eight years, zero *Acacia* pollen was recorded in June, the exception being 2023 when, based on the phenology observations (fig. 1), the most likely source was *A. baileyana.*

Pollen catch profile for 2023

The pattern was distinctly bimodal with a major peak in August/September and a smaller one in November (fig. 1). From the phenological data in figure 1, only *A. mearnsii* was flowering at the latter time. From the end of July to the third week in September double-digit *Acacia* catches were recorded each week.

For quantitative comparison we also report the weekly catch of *Pinaceae* (almost certainly *P. radiata*) pollen and also the total of all 27 plant taxa combined. The pattern for *Pinus* mirrored that of most *Acacia* species, being highest from late July to the end of September; however, there was an order of magnitude difference in the amount of pollen caught in those nine weeks (135 polyads for *Acacia* and 1,336 grains for pine). The highest concentration of *Acacia* pollen on 22 September was 7.1 polyads/m^3, with the highest *Pinus* catch being 88.8 grains/m^3 on 14 September. For all plant taxa combined, the catch was 8,047. *Acacia* therefore represented only 1.7% of all pollen in the atmosphere.

TABLE 2 — Selected weather parameters for the day prior to days of zero (Set 1) or high (Set 2) pollen catches, during the months of August and September 2023

Observation dates	No. pine pollen grains	Max temp (°C)	RH% 3 pm	Max wind gust km/hr	Wind speed 3 pm km/hr	Wind direction 3 pm[1]
SET 1						
7-Aug	1	15.0	59	37	9	SE
9-Aug	5	15.3	57	28	17	ESE
15-Aug	9	12.0	51	26	11	ESE
16-Aug	10	13.1	50	26	9	NE
21-Aug	7	17.2	47	48	19	NW
23-Aug	5	12.4	87	46	7	SE
27-Aug	0	12.1	51	31	15	ESE
29-Aug	5	15.3	59	30	9	SE
30-Aug	0	19.3	41	44	17	NNW
3-Sep	3	13.7	59	28	15	SE
4-Sep	9	18.1	43	33	13	NNE
5-Sep	0	21.6	38	61	20	N
9-Sep	12	16.4	43	57	24	NNW
11-Sep	27	16.5	78	52	7	NNE
12-Sep	39	12.5	50	44	9	SE
18-Sep	44	17.3	35	87	35	WNW
20-Sep	0	22.9	21	104	21	NW
21-Sep	0	13.5	75	72	19	NW
SET 2						
10-Aug	50	14.1	47	44	13	N
19-Aug	37	13.3	52	56	20	SW
20-Aug	38	17.4	51	69	26	NW
22-Aug	44	19.1	38	65	35	WNW
25-Aug	57	19.0	44	50	26	NW
31-Aug	24	14.7	54	50	17	SSW
7-Sep	33	18.0	40	63	31	NW
15-Sep	46	20.9	64	41	15	E
16-Sep	43	20.3	36	72	30	NNW
22-Sep	1	11.9	73	50	28	SSW

	Set 1 - zero pollen	Set 2 - high pollen	Significance of difference (2-tailed t test)
Max temperature °C	15.8	16.9	n.s.
RH% 3pm	52.4	49.9	n.s.
Max wind gust (km/hr)	47.1	56.0	n.s.
Wind speed 3 pm (km/hr)	15.3	24.1	P<0.01
Rainfall (mm)	1.2	0.9	n.s.
Pine pollen catch	10	37	P<0.001

[1] By Chi-squared test, frequency of days with wind from SSW- N sector was significantly different between Sets (P<0.05).

Relationship between pollen catch and ambient weather conditions

The differences in weather variables for the Sets of days during August/September 2023 with zero and high *Acacia* pollen catches are shown in table 2. The only statistically significant relationship was with 3 pm wind speed, which was lower (15.3 km/hr) on zero days (Set 1) than the average of 24.1 km/hr on the days with high catch (Set 2). For six of the ten Set 2 days the 3 pm wind direction was between WNW and N. For the other traits, mean differences between Sets varied in the expected direction (relatively higher temperature, lower 3 pm RH% and higher maximum wind gust speed for Set 2) but there was sufficient variation within sets that these were not statistically significant. The average catch of *Pinus* pollen was also significantly less for Set 1 than for Set 2 (10 cf. 37 grains).

The weather records for each of the weeks of highest *Acacia* pollen catch in July, August and September respectively (fig. 1) showed that each includes a period of two or more days with higher temperature, lower RH% and more wind run than the respective monthly means (table 3). From the pattern of *Pinus* and total pollen catches during the high *Acacia* catch weeks it is clear that the weather conditions at those times was generally conducive to pollen dispersal. For *Pinus* the same weeks had the highest catch of the respective months (fig. 1) and for all three pollen categories the catch during those weeks was higher than for either the previous or following weeks.

DISCUSSION

The primary aim of the study was to increase understanding of the potential role of wind as a pollen vector for species of *Acacia* growing in SE Tasmania. This is important because the pollination syndrome of a species has a profound effect on its mating system and hence genetic structure of populations (Ellstrand 2014). Pollen flux will vary with the type of vector responsible for transfer between plants. Biotic vectors can have the advantage of effecting more precise pollination during feeding, but gene flow distances will be influenced by their behaviour, which may be quite localised. The populations of effective biotic vectors relative to the number of flowers requiring pollination, is also an important variable (Faegri & Van der Pijl 1979, Griffin *et al.* 2009). In contrast, wind can reliably disperse pollen over substantial distances (Robledo-Arnuncio 2011) and, for species with predominantly hermaphrodite flowers such as *Acacia*, the amount of pollen produced should vary directly with the number of ovules requiring pollination. The risk of pollen limitation should therefore be less than with biotic vectors. The seasonal phenology of a species determines probable weather conditions during flowering which will most likely impact the relative importance of insects and wind as pollen vectors.

Phenology and seasonal variation in pollen catch

Consistent with knowledge that a large proportion of *Acacia* species in SE Australia flower in late winter to mid-spring (Bernhardt 1989, Costermans 2009), all but three of the 16 species on campus completed flowering between late July and early October (fig. 1 and app. 2). The strong year-on-year repeatability of this pattern can be inferred from the pollen catch data (fig. 2). Tng *et al.* (2010) also reported that in 2007 local *Acacia* pollen catch was maximal in September. It is pertinent to note that species from four different taxonomic sections (table 1) were all flowering at this time suggesting that whatever evolutional force has shaped this aspect of the reproductive biology, it is general to the genus.

Pollen caught during early July can be attributed to *A. baileyana* (fig. 1), the nearest plant of which was 185 m from the sampler. The most common taxon in the study area, *A. mearnsii,* must be responsible for the secondary peak in pollen catch during November–December since it is the only species with significant flowering at that time. Moncur *et al.* (1991) reported that, following periods of medium to strong winds, they were able to trap pollen downwind of trees of this species. Variation in yearly amplitude of the November/December peak (fig. 2) is most likely due to variation in flowering intensity of the only flowering species, *A. mearnsii*. Its flowering in 2023 was relatively light while in 2021 a hot dry spring caused inflorescence buds to dry off prior to anthesis (Griffin

TABLE 3 — Meteorological conditions during weeks of highest *Acacia* pollen catch in 2023 for months of July, August and September (refer fig. 1 and table 2)

Month	Week	Total *Acacia* polyads	Two-day or more spell warm weather	Mean max temp °C	Mean 3 pm RH%	Total rainfall (mm)	Max wind gust (km)	Corresponding monthly mean values		
								Max temp	3 pm RH%	Wind gust
July	4	18	28–29/7	17.9	41.5	0.2	65	15.0	54.0	59
August	3	26	19–21/8	17.9	44.0	0.0	61	15.2	53.5	46
September	2	25	13–15/9	21.5	42.0	0.6	57	17.0	51.0	57

unpubl. observation). If reproductive output of *Acacia* is strongly limited by dependence on insect vectors, an adaptive shift to summer flowering might be expected, but except for *A. mearnsii,* this is not evident.

Pollen dispersion

The seasonal variation in pollen catch broadly reflected the flowering phenology (fig. 1) although we should not assume that all of the pollen did in fact originate on-site. The mean distance of plants from the pollen trap for the six species in full flower in late August, was 150 m (table 1). Of these only *A. dealbata* is of tree-form, with the nearest individual 65 m from the trap. There were several plants of the large shrubs *A. pravissima* and *A. howittii* 35 m from the trap building.

For the specialised wind-pollinated *Pinus*, a regional origin is clear since there were no trees on-site or even nearby. The most likely source was *P. radiata* which is extensively planted for wood production in Tasmania and flowers at the same time as the peak *Acacia* season (S. Hetherington pers. comm.). Griffin (1980) found that pollen density of this species attenuated over about 200 m from a point source on a calm day but was uniform for at least 1 km on a day with wind run averaging over 21 km/hr, so transportation over tens of kilometres would not be unusual.

Relationship with weather conditions

The particular weather variables analysed were chosen with reference to the literature. In general, pollen dispersion is favoured by dry warm conditions (Niklas 1985, Shramm *et al.* 2021). Stone *et al.* (1998) found that anthesis in species of Africa *Acacia* spp. was strongly correlated with ambient Relative Humidity (RH)%. Air turbulence is an important determinant of airborne pollen dispersion (Knox 1979) and Prescott (2005) reported that pollen shed from a number of *Acacia* species in Victoria was greatest from late morning to mid-afternoon. Niklas (1985) also refers to the phenomenon of 'raindrop scavenging' or the elimination of airborne pollen by rain.

Atmospheric conditions affect two distinct aspects of the reproductive processes – anther dehiscence and hence the availability of pollen for dispersion, and the transport of pollen *per se* (Niklas 1985). Irrespective of wind speed, pollen will not be captured if preceding conditions, particularly RH% (Stone *et al.* 1998), are not conducive to dehiscence. Conversely, pollen will not be dispersed from dehisced anthers unless wind speed passes some critical threshold. A wind tunnel experiment (Griffin unpubl. data) has shown that *A. dealbata* pollen begins to blow off flowers once the wind speed reaches 10 km/hr, with quantities increasing linearly to at least 35 km/hr. In this study we were not able judge the extent to which these traits separately affected pollen catch; however, from the significant association with 3 pm wind speed it is reasonable to assume that on days with relatively high catch, the temperature and RH% were adequate for dehiscence and therefore we had observed the effect of wind speed on dispersal. Mean wind speed on those days was 24.1 km/hr compared to 15.3 km/hr on days with zero catch (table 2). However, since wind speed was less than 10 km/hr on only six of the 18 zero catch days, it seems likely that weather effects on dehiscence were also important.

Pollen flux

Aside from the ambient weather conditions, seasonal phenology and density of the plant population, pollen flux will be influenced by the amount of pollen produced per plant which will vary with the number of flowers and the pollen grains per flower. Acacia flowers typically bear many stamens. Flowers of one of the dominant local species, *A. dealbata,* contain an average of 33 stamens (Correia *et al.* 2014). Each stamen carries a two-locule anther commonly containing 8 x 16 grain polyads which is a distinctive feature of this and other genera of Mimosaceae. Cruden (1977) reported a wide variation in the pollen:ovule (P/O) ratio of flowering plant taxa with different breeding systems, averaging over 5,000 for obligate outcrossers and less than 200 for those which are self-fertile. Bernhardt (1984) estimated a P/O ratio of 640 for *A. retinodes* which, if we accept that *Acacias* are generally outcrossers, is on the low side. However, it is common to find that some flowers within a head are only male, and if we consider the multi-flowered inflorescence to be the effective pollination unit (Kendrick 2003), the ratio will be correspondingly increased. A distinctive feature of *Acacia* is that pollen grains are also clustered in polyads (Coetzee 1955, Kendrick & Knox 1982) with the number of grains comparable to the number of ovules per flower, so a single polyad alighting on a stigma is sufficient for full seed set. Cruden (1977) described this as a 'sweepstakes' pollination system, i.e., there is a low probability of successful pollen transfer, but a high reward in terms of seed set when this does occur. An *Acacia* polyad is relatively large (39 <70μ) (Coetzee 1955) and similar in size to *Pinus* pollen grains (45<65μ) (Cain 1940), each of which has two air sacs assisting flight. Loss of water content on release influences both the mass and form of pollen (Niklas 1985). Niklas observed that 'the corpus of *Pinus taeda* grains assumes a concave-convex shape effecting a botanical "frisbee"' (Niklas 1985, p. 335). Although unproven, the furrowed disk-like form of a polyad (Coetzee 1955) may have similar aerodynamic benefits.

The amount of flowers and therefore pollen produced will vary between *Acacia* species of different plant forms, but is clearly nowhere near that of *Pinus*. Khanduri and Sharma (2002) estimated a P/O ratio of about 5,000 for *P. roxburghii* and a mature radiata pine tree can produce up to 0.75 kg of pollen or 300 kg/ha of plantation every year (Scion 2017). It is therefore not surprising that our catch of pine pollen was an order of magnitude higher than for *Acacia* (fig. 1).

Different pollens have a characteristic settling velocity under calm conditions (Gregory 1973) with concentration downwind of a point source diminishing at a rate inversely proportional to the square of the distance travelled (Niklas 1985), but this no longer holds as turbulence increases (Faegri & van der Pijl 1979, Knox 1979, Sedgley &

Griffin 1989). In general, turbulence is much stronger than the rate of fall of pollen grains (Gregory 1973) and the gradual attenuation of pollen content in the air is due to diffusion rather than fall out (Faegri & van der Pijl 1979). Pollen dispersion is therefore most likely different from *Acacia* species with different growth habit, being greater from trees than smaller shrubs. Knox (1979) illustrated the point with a calculation that pollen released from a height of 1 m might travel 67 m before deposition whereas with release at 20 m it would travel 1,333 m. Each of the regionally common tree-form species, *A. dealbata* and *A. melanoxylon* (which flower during August–September), and *A. mearnsii* (November–December), can grow substantially taller than this and it seems highly likely that some of the *Acacia* pollen originated beyond the study area. In the context of pollination within natural populations, wind dispersal beyond 300 m could effect crosses between many different genotypes, not only within but between populations, and could explain the mechanism of gene flow between disjunct populations up to 1.9 km apart in *A. woodmaniorum* reported by Millar *et al.* (2014). Those authors suggested wind dispersion, but of pollen-bearing insects, rather than of polyads *per se.*

It is clear from the week-to-week variation in catch (fig. 1) that pollen is not shed uniformly through the flowering season of any of the species; however, given the rather lengthy flowering period of the spring-flowering species (an average of nine weeks) it is extremely likely that they will experience periods of suitable weather conditions at some point (see table 3). Weeks which were high for *Acacia* pollen also had particularly high catches of *Pinus* and total pollen (fig. 1, table 3) so it is reasonable to conclude that such conditions are generally favourable for pollen dispersion.

The fact that *Acacia* pollen can be wind-dispersed is not new. However, the idea that the pollination syndrome of this large, Australia-wide genus, should more correctly be described as ambophily is not well-developed in the literature. For two of the early flowering species in this study, there is supportive evidence. In Portugal, Giovanetti *et al.* (2018) reported pod set on *A. longifolia* within insect exclusion bags and argued for a role of wind as a vector. Secondly, the locally common species *A. dealbata* is known to set heavy crops of seed in the absence of substantial populations of biotic vectors (Griffin *et al.* 2020). Genetic analysis by Broadhurst *et al.* (2008) confirmed that NSW populations of this species are strongly outcrossed, which leaves wind as a likely vector responsible for the high level of cross-pollination inferred from the local seed crops. The phenology data reported in the current study confirmed the high concentration of flowering of temperate *Acacias* in late winter–early spring. If reproductive output is strongly limited by dependence on insect vectors one might expect an adaptive shift towards summer flowering, which, apart from *A.mearnsii,* is not apparent. We have been able to show that during July–September there were periods of weather conducive to pollen dispersion although at much lower levels than that observed for the specialised wind-pollinated *Pinus radiata*. Whether the observed flux is sufficient to effect a high level of seed set will require species- and population-specific field investigations.

The importance or otherwise of wind pollination has major implications for understanding the reproductive system, gene flow and population structure of *Acacia* species and justifies ongoing experimental studies designed to demonstrate the efficacy of wind, an ever-present feature of the weather in SE Tasmania, as a pollen vector. This is a challenging task requiring careful selection of a model species and study site; timely insect exclusion bagging; parallel quantification of insect visits; full environmental monitoring; and adequate replication to demonstrate statistical significance.

In a wide-ranging review of key questions in pollination ecology research, Mayer *et al.* (2011) noted increased reports of anemophily in otherwise entomophilous plant families (see also Culley *et al.* 2002). They identified key research questions: when, where and how did evolutionary shifts from biotic to abiotic pollination systems occur?; what are the biophysical mechanisms involved in abiotic pollination?; and is ambophily a stable or transitory evolutionary phenomenon? There are currently 1,082 described species in the genus *Acacia* (Murphy & Maslin 2023), adapted to a wide range of environmental conditions from Papua New Guinea through arid zone Australia to the temperate SE regions. About one-third of these are small- to medium-sized trees, a plant form favouring wind dispersion of pollen under suitable weather conditions, and the genus would be well-suited for comparative study of these unresolved questions.

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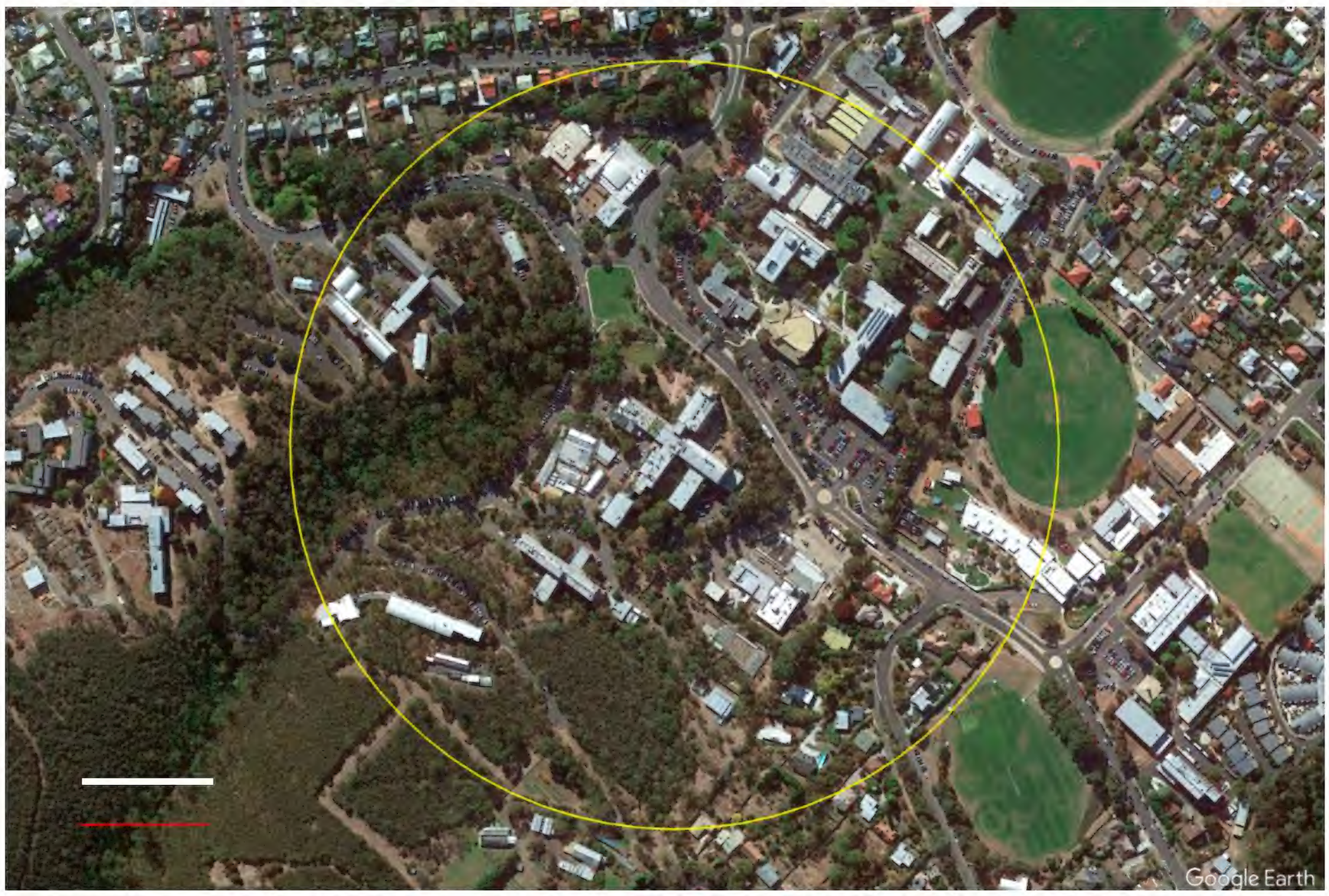
APPENDIX 1

The University of Tasmania's Sandy Bay campus showing study area within 300 m of pollen sampler on Zoology building roof. Scale bar represents 100 m.



APPENDIX 2

Flowering phenology of minor species observed in the 2023 phenology study on University of Tasmania Sandy Bay campus

Acacia species	Section[1]	Habit	Total no plants	Mean distance (m) to pollen trap	Distance to nearest plant (m)	Date of first flowering	Date of last flowering[2]
A. cultriformis	Acacia[3]	small shrub	2	100	100	Aug. 15	Sep. 17
A. fimbriata	Acaci [3]	small shrub	2	210	185	July 29	Sep. 17
A. pycnantha	Acacia[3]	small shrub	1	100	100	Sep. 7	Nov. 14
A. stricta	Acaci [3]	small shrub	2	240	240	Aug. 28	Oct. 1
A. uncifolia[2]	Acacia[3]	large shrub	5	60	35	July 8	(March 2024)
A. mucronata	Juliflorae	small shrub	1	35	35	Aug. 21	Oct. 1

[1] After Murphy & Maslin 2023.
[2] Species still flowering beyond end of this study until at least March 2024 and presumed responsible for five polyads recorded in January and two in February 2024.
[3] syn. Section Phyllodineae.

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POPULATION TRENDS OF WOODLAND BIRD SPECIES IN THE CLARENCE LOCAL GOVERNMENT AREA, SOUTHEAST TASMANIA

by Mike Newman and Eric J Woehler

(with two figures and one table)

Newman, M & Woehler, EJ (2025). Population trends of woodland bird species in the Clarence Local Government Area, southeast Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 159: 17–22. ISSN 0080-4703. Acton Park Tasmania 7170, Australia (MN*); Australasian Seabird Group, PO Box 1741, Tasmania 7001, Australia (EJW). * Author for correspondence. Email: omgnewman@bigpond.com

Monthly monitoring was initiated in 2015 and continued for 10 years at 20 peri-urban sites in the Clarence Local Government Area (LGA) in southeast Tasmania to identify the trajectories of bird populations. A total of 869 surveys were undertaken and 78 bird species recorded. The 2 ha survey sites were in a range of locations and monitored in the mornings for 20 minutes during the post-breeding season (January–April). There was a statistically significant decrease of 21% for the decade in the number of species recorded per survey, indicating a long-term decrease in species diversity at the survey sites. Nine of the 21 most frequently recorded species (43%) had relatively stable populations over the 10 years. The predominant trend of the remaining species was a decrease, with six species' decreases statistically significant. Three species increased, one statistically significantly. Of greatest concern was the decrease of two Tasmanian endemic species: dusky robin and black-headed honeyeater, with both decreases highly significant at greater than 70% for the decade. The strongly decreasing species were small insectivores, consistent with global trends, attributed to decreases in insect populations. Many factors associated with climate change and progressive forest degradation potentially contribute to these losses and may be particularly severe in the study area, which already has a below average rainfall. These decreases in species diversity and abundance in a local bird community are of alarming magnitudes and the cause(s) need to be identified and addressed.

Key Words: bird population trends, Clarence, Tasmania, endemic bird decreases, dusky robin.

INTRODUCTION

Many factors, both natural and anthropogenic, contribute to fluctuations in the abundance of bird populations. Short-term variations in response to changes in climatic conditions (e.g., rainfall and temperature) are a feature of stable bird populations, but over an extended period equilibrium is maintained for most species. Anthropogenic factors may destabilise bird populations, resulting in long-term changes, both decreasing and increasing, that are difficult to prove (Bennett *et al.* 2024). The impacts to populations can be direct (e.g., land clearing, habitat modification, disturbance and the introduction of exotic predators), or indirect anthropological activities (e.g., global warming). Newton (2013) provided a comprehensive overview of the complexity associated with understanding the dynamics of bird populations. For instance, a species may respond to favourable conditions by increasing its numbers locally or increasing its range. Species may be sedentary, migratory or locally nomadic resulting in seasonal differences of occurrence, further complicating the evaluation of survey results.

Bain *et al.* (2020) identified both decreasing and increasing trends in bird populations inhabiting remnant woodland patches in the Tasmanian Midlands by comparing the results of monitoring efforts 20 years apart. Ideally, such monitoring would be continuous to allow the distinction between short-term fluctuations and long-term changes to be identified. However, some species may take 15 or more years to return to equilibrium following extreme events such as the Millennium Drought 2000–2009 throughout southeast Australia (Bennett *et al.* 2024). While several long-term studies of seabird and shorebirds provide that longevity, there are few suitable studies of woodland birds in Australia.

In this paper, we examine evidence for long-term changes in bird populations in the remnant woodlands of the Clarence Local Government Area (LGA) in southeast Tasmania. This is a peri-urban landscape where changes in land use associated with expanding residential development were expected to influence the stability of local bird populations. We investigate the evidence of long-term population changes from anthropogenic factors superimposed on the natural rainfall-related fluctuations. To address the challenges described in Newton (2013), we evaluated annual differences in the frequency of observation of woodland bird species in the post-breeding season (January–April), when populations are at a maximum, over a period of 10 years.

METHODS

Morning surveys were conducted on one day/month at 20 x 2 ha surveys sites around the Clarence LGA (fig, 1), coinciding with the daily peak of bird activity. All observations were undertaken by the lead author, and the study is ongoing. The presence of all bird species seen and heard, including

birds flying overhead, was recorded during the 20-minute surveys according to a standardised technique (https://birdata.birdlife.org.au/help/survey-techniques). Six sites were in uninhabited dry forest in the Meehan Range that are recovering from a wildfire in October 2006. Eleven sites were in dry woodland on large acreage residential properties on the western side of the South Arm Peninsula, and three sites were in coastal vegetation located in small reserves on the South Arm Peninsula (fig. 1). Presence data were presented as a Reporting Rate (RR), indicating the percentage of surveys in which a species was recorded, and used as a surrogate measure of species abundance. Mean list length/survey was used as the measures of species diversity and change in the total bird population in this study (Szabo *et al.* 2010).

The analyses presented here are based on presence data for the post-breeding season (January–April) for the 10 years. These sites were selected because they had been monitored for the 10-year period 2015–2024 inclusive, thus eliminating sampling bias. Linear regressions were conducted on species with RR ≥ 10% and present

FIGURE 1 — Map of the South Arm Peninsula showing the locations of the 20 sites monitored 2015–2024, inclusive. Meehan Range sites are shown in orange (n = 6), dry forest in yellow (11) and coastal reserves in purple (3). Scale bar shows 10 km.

throughout the post-breeding season, which eliminated summer visitors (e.g., cuckoo species) because they departed early and were only present for part of the post-breeding season.

All trend analyses and plots were undertaken using DataGraph 5.3 software (https://www.visualdatatools.com/DataGraph/). Statistical significance was assessed at 5% and 1% levels (Sokal & Rohlf 1995). The slopes of linear correlations were used to assess the decadal rates of population change and the Coefficient of Determination r^2 was used to identify candidate species for statistical testing as an indication of the extent to which annual variation was time-dependent.

RESULTS

A total of 869 surveys were undertaken and 78 bird species recorded. The annual post-breeding season (January–April) variation in the mean list length (number of species recorded/survey) showed a statistically significant ($0.05 > p > 0.01$) decreasing trend in the species diversity at the survey sites during the 10 years (fig. 2). The relative linear rate of decrease was 21% per decade, and 41% of the variation in the species list lengths over the 10 years was explained by year.

Linear regressions of the 21 most frequently recorded species (Reporting Rate ≥ 10%) were used to identify the species' population trends (table 1). Of the 21 species evaluated, populations of 13 species were decreasing, including six trends that were statistically significant ($p < 0.05$), including three highly significant trends ($p < 0.01$). Of the eight species with increasing trends, only one was statistically significant ($0.05 > p > 0.01$) (table 1).

Nine species had Coefficients of Determination of less than 0.1, indicating the long-term trend explained < 10% of the annual variation in Reporting Rate, and that their populations were relatively stable. For the remaining five species, four species' populations were decreasing and one was increasing. These species had elevated Coefficients of Determination (e.g., spotted pardalote 0.39 and forest raven 0.33), indicating the possibility of a change in population during the survey period, but not at a statistically significant level.

DISCUSSION

A mix of increasing, decreasing and relatively stable species, with a predominance of decreasing trends (13/21 species, 62%) was identified among the 21 species examined in this study. This predominance of decreasing populations is consistent with the overall statistically significant decreasing trend of 21% per decade for all species recorded during the surveys. These results indicate a decrease in the diversity of a local bird community of alarming magnitude in a relatively brief period of 10 years. Changes of such magnitude over brief periods require the causes to be identified and addressed urgently.

Decreasing species

The six species with statistically significant decreasing trends are relatively small-bodied insectivores. They exploit a range of foraging niches including the ground (scarlet and dusky robins), foliage and branches (golden whistler and black-headed honeyeater) and two aerial hawkers (grey fantail and dusky woodswallow). Their decadal rates of

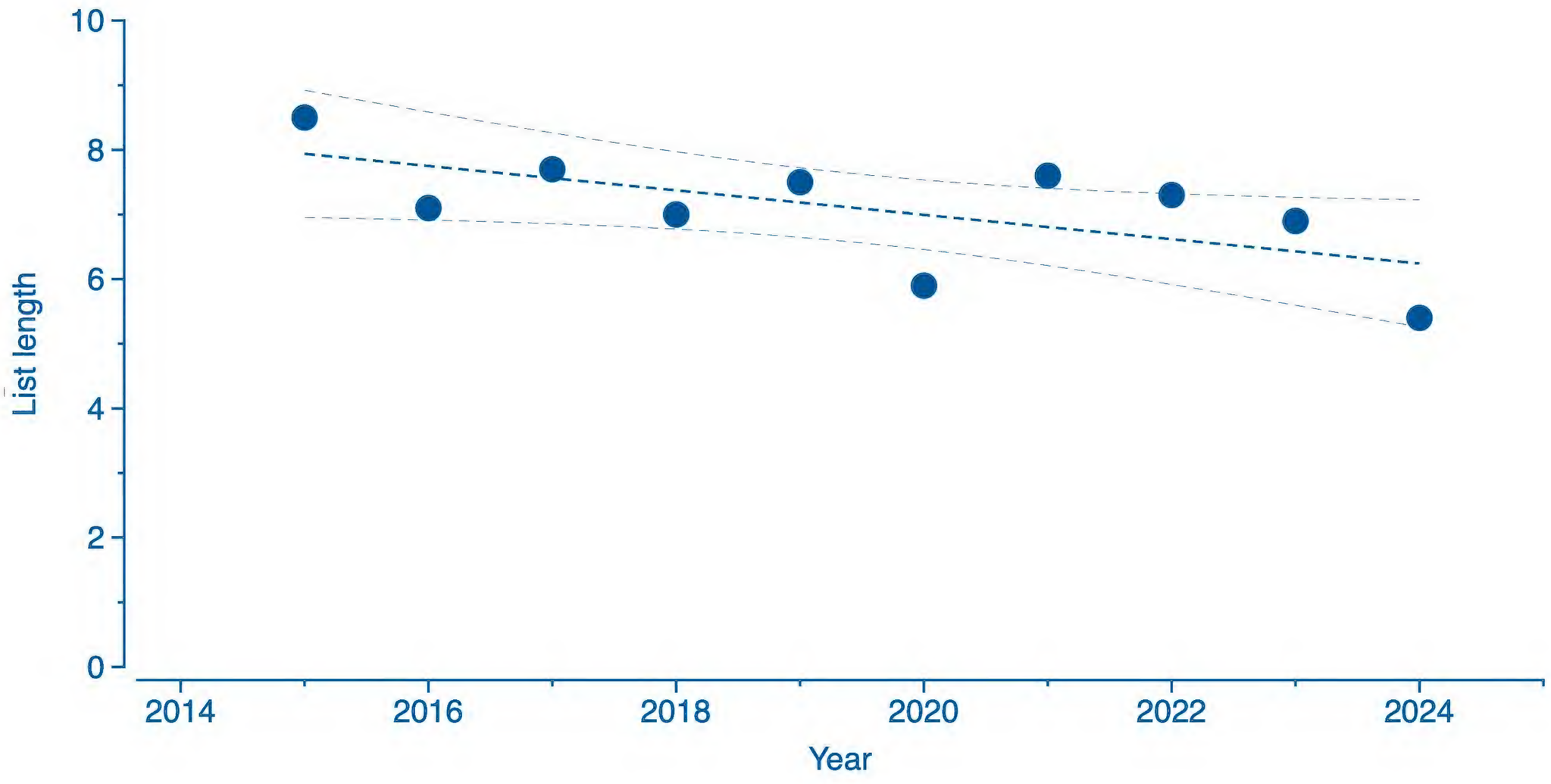

FIGURE 2 — Linear regression of the mean list length of species recorded in post-breeding season surveys in the Clarence LGA, southeast Tasmania.

TABLE 1 — Comparison of the post-breeding season annual Reporting Rate trends of the 21 most frequently recorded bird species (Total Reporting Rate ≥ 10%). The species are ranked on the rate of decadal decrease.

Bird species	Reporting rate (%)	Decadal change (%)	Coefficient of determination r^2	Statistical significance
Grey butcherbird *Cracticus torquatus*	12.8	166.7	0.41	S
Grey currawong *Strepera versicolor*	12.2	34.4	0.06	NS
Forest raven *Corvus tasmanicus*	54.4	33.8	0.33	NS
Common bronzewing *Phaps chalcoptera*	10.0	28.6	0.05	NS
Grey shrike-thrush *Colluricincla harmonica*	42.8	25.6	0.08	NS
Little wattlebird *Anthochaera chrysoptera*	20.3	10.2	0.02	NS
Yellow-throated honeyeater *Lichenostomus flavicollis*	77.1	4.0	0.02	NS
Silvereye *Zosterops lateralis*	12.9	0.2	0.00	NS
New Holland honeyeater *Phylidonyris novaehollandiae*	29.5	–10.2	0.05	NS
Green rosella *Platycercus caledonicus*	46.5	–14.1	0.08	NS
Superb fairy-wren *Malurus cyaneus*	34.1	–25.8	0.18	NS
Brown thornbill *Acanthiza pusilla*	40.9	–34.0	0.28	NS
Spotted pardalote *Pardalotus punctatus*	40.8	–37.0	0.39	NS
Laughing kookaburra *Dacelo novaeguineae*	10.2	–38.7	0.10	NS
Grey fantail *Rhipidura albiscapa*	41.7	–44.1	0.52	S
Striated pardalote *Pardalotus striatus*	22.7	–45.8	0.19	NS
Golden whistler *Pachycephala pectoralis*	21.2	–61.0	0.49	S
Scarlet robin *Petroica boodang*	16.1	–63.7	0.52	S
Dusky woodswallow *Artamus cyanopterus*	11.2	–70.9	0.69	HS
Dusky robin *Melanodryas vittata*	15.1	–90.0	0.86	HS
Black-headed honeyeater *Melithreptus affinis*	10.1	–96.8	0.64	HS

NS = Not significant $p>0.05$
S = Significant $0.05 > p > 0.01$
HS = Highly significant $p<0.01$

decrease exceeded 40%, an alarmingly high rate that could cause local extirpation unless addressed. Several other small insectivorous species also decreased over the 10 years, but the trends were not statistically significant. These included the canopy foraging spotted and striated pardalotes, brown thornbill and superb fairy-wren, the latter two species often foraging in association in understorey and ground vegetation, respectively. There was one exception to this generalisation, the laughing kookaburra, a large mainly carnivorous species, which decreased at a similar rate to the four previously mentioned species.

Increasing species

In contrast, the species that showed the most pronounced increasing trends over the 10 years, grey butcherbird (statistically significant), grey currawong and forest raven are all large-bodied and primarily carnivorous birds.

Stable species

The five species whose populations showed the greatest evidence for stability over the 10 years were an eclectic group. They included the most frequently recorded species, the yellow-throated honeyeater, a versatile endemic honeyeater that has adapted to exploit the bark-foraging opportunities afforded by the absence of treecreepers and sitellas in Tasmania (Davis 2013). Two other honeyeaters – little wattlebird and New Holland honeyeater – are primarily floristic species with a preference for *Banksias*. The green rosella, another frequently recorded species, and silvereye both have diverse diets and exploit a range of foraging niches.

Causes of long-term decrease

The predominance of arboreal foraging species in the guild of decreasing species has been reported internationally (e.g., Ramos *et al.* 2020, Pollock *et al.* 2022), nationally (Vesk & Mac Nally 2006, Franklin *et al.* 2023, Bennett *et al.* 2024) and in Tasmania (Bain *et al.* 2020). These

decreases are often associated with corresponding increases in large-bodied bird species, a finding that was apparent to a limited extent in this study. In this study, the decreasing bird species were predominantly insectivores, and as other studies have shown, global decreases in insect populations are the cause of the observed decreases in insectivorous birds. Decreases in insect populations have been attributed to many factors including climate change-induced drying of the environment, pesticides, deforestation, and wild and fuel reduction fires (Sánchez-Bayo & Wyckhuys 2021, Wagner *et al.* 2021), all of which may be relevant to this study.

In the Clarence LGA, the importance of some of the above causative factors may be exacerbated. For instance, the study area is in a below average rainfall area on the southeast coast of southern Tasmania, where the impacts of climate change-induced drying might be expected to be amplified at a regional scale (Remenyi *et al.* 2020). While much of the LGA remains well-forested and is not subject to large-scale deforestation, urban development has caused and continues to cause progressive (and in some cases, accelerating) forest loss and fragmentation, particularly in the peri-urban areas of the South Arm Peninsula. Despite this deterioration, forest integrity remains sufficient to prevent the despotic noisy miner being a dominant influence on the composition of bird populations at the survey sites (Newman 2013, Bain *et al.* 2020). Areas involving low-density habitation result in progressive opening of the forest attracting avian nest predators (e.g., currawong) and exotic predators such as domestic and feral cats.

Species severely affected

The three species that had highly significant linear regressions with rates of decadal decrease exceeding 70% included two Tasmanian endemics: black-headed honeyeater and dusky robin. As black-headed honeyeaters are a preferred host of pallid cuckoos, any decrease in this species may potentially cause a concomitant decrease in the pallid cuckoo population within the study site, but this has not occurred to a similar extent (Newman 2021). This disparity may reflect the plasticity in species' nests parasitised by pallid cuckoos throughout southeast Tasmania (M Newman, pers. obs.).

Dusky robins exhibited a 90% decadal decrease during the study period. This alarming finding reflects similar trends in other datasets showing significant decreases in this species statewide and where habitat fragmentation has been identified as a contributing cause in observed population decreases. The finding supports the recent assessment of the dusky robin as meeting the criteria of Vulnerable under Tasmania's *Threatened Species Protection Act 1995* (Newman *et al.* 2021).

The third species showing a rapid decrease was the dusky woodswallow, a summer visitor to Tasmania with a nomadic disposition. Hence, the cause of their decrease may not be directly related to conditions within the study area but widescale environmental factors influencing their distribution at a national level.

Strengths, limitations and future application of the methodology

Limiting monitoring to the post-breeding season has the advantage of simplifying data analyses by eliminating seasonal biases. However, it does restrict the number of species that have sufficient data for statistically valid analyses (e.g., several summer migrants, including the cuckoos). The statistical power of the present study's methodology was enhanced by the longevity of the study (10 years) and the highly structured sampling regime (i.e., one observer conducting replicated standardised surveys at regular intervals). However, even 10 years may be insufficient for a species to reach equilibrium, particularly species with long generation times (Bird *et al.* 2020). Decadal trends are usually sufficient for small insectivorous species that have short generation times (Garnett & Baker 2021, Newman *et al.* 2021). In cases of climate instability, even longer time series population data may be necessary (Bennett *et al.* 2024), a situation that probably applies in this study. It is intended to extend this analysis to the evaluation of monthly surveys conducted throughout the year in future species-specific studies of priority species (e.g., dusky robin) for which for there is immediate conservation concern (Garnett & Baker 2021, Laroche & Taylor 2024, Wright 2024).

CONCLUSIONS

In this decade-long study undertaken in peri-urban habitat in the Clarence LGA, the dominant trend was for species to decrease in surveys at 20 sites for the post-breeding season, January to April. This was manifested in a 21% decadal decrease in the mean species list length, a measure of species diversity. Six species had statistically significant ($p < 0.05$) rates of decadal decrease, of which three were highly significant ($p < 0.01$) with decadal rates of decrease exceeding 70%; two of these three species were Tasmanian endemics (dusky robin and black-headed honeyeater). Only one species' population in the study increased statistically significantly.

Small insectivorous species dominated the guild of decreasing species, consistent with a global trend associated with diminished insect populations. Climate change is drying numerous habitats throughout Tasmania (Wright 2024), and habitat clearing and degradation associated with urban development (Laroche & Taylor 2024) are all significant contributing factors that stand out in the context of this study. These factors are in effect throughout Tasmania (Laroche & Taylor 2024, Wright 2024), and likely to be influencing bird populations to varying degrees elsewhere (e.g., Newman *et al.* 2022). Attributing the relative roles of anthropogenic and environmental influences on bird populations (Newton 2013, Bennett *et al.* 2024) is made more difficult with the synergies and interactions now in effect at a range of spatial and temporal scales (e.g., Bain *et al.* 2020, Lindenmayer 2022).

The long-term trends identified in this study are primarily attributed to anthropogenic influences associated with low-density urbanisation and the concomitant progressive loss of natural woodland and associated values, which is occurring elsewhere within the Clarence LGA. Habitat loss and modification arising from vegetation clearing and associated fire management have been compounded by the spread of exotic predators such as domestic and feral cats (*Felis catus*) and the establishment and subsequent expansion of carnivorous species such as grey currawong and grey butcherbird, both of which are known nest predators (Fulton 2018). It may be that natural influences, such as variations in annual and seasonal rainfall cause short-term population variations which are compounded with the effects of extended periods of warmer and drier conditions (Grose *et al.* 2023), leading to the observed instabilities of bird populations.

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(accepted 31 March 2025)

THE ENIGMA OF BARNARD'S MAP OF KING ISLAND

by Adelina Latinovic, Peter Devine and Anne Kitchener

(with one figure and one appendix)

Latinovic, A, Devine, P & Kitchener, A (2025). The enigma of Barnard's map of King Island. *Papers and Proceedings of the Royal Society of Tasmania* 159: 23–26. ISSN: 0080-4703. Department of Natural Resources and Environment Tasmania, 134 Macquarie Street, Hobart, Tasmania 7000, Australia (AL*, PD, AK). *Author for correspondence. Email Adelina.Latinovic@nre.tas.gov.au

Drawing on the interpretation of archival information and historical anecdotes, this paper identifies George William Barnard as the author who produced a historic map of King Island, Tasmania, recording information collected in the summer of 1826–1827. These findings ensure the chronology of historical knowledge is maintained and enable institutions to improve metadata for existing copies of this map.

Key Words: King Island, Kings Island, colonial surveys, historical map, Van Diemen's Land, Tasmania.

One of the earliest comprehensive surveys of the rocks, timber and soil of King Island, known as King's Island until 1917 and named after Governor Philip Gidley King (Dennison 1994), is contained on a map, the true author and date of which have remained an enigma lost in the passage of time (fig. 1A). Three copies of the same map of the island have been interpreted as dating from anywhere between 1825–1826 and 1850–1880 (appendix A). Proclaimed on the top leftmost corner of the map (fig. 1A), 'Kings Island – from Scotts survey' elicits confusion as to which of the Scott brothers' surveys was the basis for the map. Whilst it is widely accepted that two Scott brothers were established surveyors in Tasmania across the period of 1825 to 1855, a closer investigation of their personal lives elucidates the survey transects were not walked by them nor penned by either of their hands.

Thomas Scott was the first of the two brothers to arrive in Van Diemen's Land (Crawford 1967, Archer 2009), where he took on work as Assistant Surveyor to the Deputy Surveyor General in 1821. From 1822–1824, Thomas surveyed the east coast of Tasmania and produced a Chart of Van Diemen's Land (Scott 1824, Crawford 1967). In 1826 he is purported to have produced a variant of this chart for military purposes, but this was not publicly published (Crawford 1967). A 'Military Chart of Van Diemen's Land…drawn by T. Scott and copied by H.S. Hurst' has been identified at the State Library of New South Wales (Scott 1826). Whilst this chart is extremely detailed, it only covers the eastern portion of the main island of Tasmania. Therefore, it is unlikely that Thomas Scott had the opportunity and resourcing to survey King Island during this period.

Whilst producing these two charts in the years 1824–1826, Thomas Scott was temporarily invited to act as Surveyor General (Crawford 1967). However, issues of bribery surrounding his mentor and superior, Deputy Surveyor George Evans, tarnished Thomas Scott's reputation so profoundly that in 1827 Governor George Arthur commented, '[Scott's] connection was too deeply associated with the improper practices…to induce me to consider myself safe with him as Surveyor General' (Watson *et al.* 1914, vol. 6, p. 535). Official Government correspondence and personal letters between the Scott brothers suggest that Thomas was not offered any work between 1826–1827 and was only retained in his original role of Assistant Surveyor after passing comprehensive testing by the new Acting Surveyor General Edward Dumaresq (Watson *et al.* 1914, Crawford 1967, Archer 2009).

In 1830 Thomas Scott became Senior Assistant Surveyor, and in 1832 he became the Surveyor of the County of Cornwall – moving from Hobart to Launceston (Archer 2009). In 1836 Thomas obtained two years' leave and returned to Scotland, having first briefly trained his brother James Scott to take over as his deputy from 1836–1838 (Crawford 1967, Archer 2009). After two years had elapsed and Thomas had not returned to Van Diemen's Land, he was deemed to have resigned from his Lands Department position (Crawford 1967, Archer 2009). Therefore, it was not possible for him to have surveyed King Island in either the periods of 1825–1826 or 1850–1880.

Although James Scott fully assumed his brother's role, he had resigned by 1853 and only undertook contract work to 1860. In personal letters between the Scott brothers (Archer 2009), James writes that little surveying work was to be done from the mid-1840s onwards. On 6 January 1851 James wrote:

> *I am occasionally employed by the Govt in surveying – having been down at Port Sorell & the Forth last month – but as they are all on fixed Salaries & live in tents constantly now – but myself, I expect they will not employ me longer than they can help…*(Archer 2009, p. 320).

He makes no mention of visiting King Island during his employment between 1836–1853.

Careful observation of one of the map copies, a digital scan held at the Department of Natural Resources and Environment Tasmania (NRE Tas), indicated that various hands have annotated the map through history (fig. 1A). The original map annotations differ from a second set which appear to have been added on 22 October 1869,

KINGS ISLAND
from Scotts survey
Ground declining, climbing Ferns, veil vegetable the top wet, Fern, cutting Grass
&c. grows so thick, that it was difficult to get to a spit of earth. Trees change
most Tea tree, some small celery leafed Pine, fine Gums, soil strong white
loam under vegetable top. small Creek standing water.

FIGURE 1A — Digital copy of Barnard's map of King Island, Department of Natural Resources and Environment. Original map measures 94 cm by 63 cm. Inset: "… Fern, cutting grass etc grows so thick, that it was difficult to get to a spit of earth. …"

FIGURE 1B – Subsequent labelling of the map as 'Kings Island from Scotts survey'.

during planning for the Cape Wickham Light House Reserve. The owner of this hand appears to have incorrectly located landmarks such as, Cape Wickham lighthouse and Victoria Cove in addition to labelling the map with, 'from Scotts survey' (fig. 1B). Pencil annotations likely dating to 1879 and the installation of Currie Lighthouse indicate a 'supposed scale one inch to the mile' of the map. However, it was observed during the digitising of transect lines from the NRE Tas copy into Geographic Information System (GIS) software, that this scale did not appear to be a good fit for the spacing between transect centroids on the map.

Interestingly, several references mention a survey of King Island by a GW Barnard in 1826. Inspection of the Tasmanian State Archives (1824–1826) and Watson *et al.* (1914) reveal a survey was conducted over the summer of 1826–1827 to investigate the suitability of King Island as a penal settlement. As a former midshipman in the Royal Navy of the United Kingdom, George William Barnard harnessed his seafaring abilities and captained his personal ship to trade goods between New South Wales and Van Diemen's Land, before settling as an agriculturalist on the right bank of the Kanamaluka/River Tamar (Bell 2020). Dissatisfied with delays from the Government in providing workers for his land, he placed an official request for employment (Bell 2020). Letters in Watson *et al.* (1914) confirm that, likely owing to his seafaring abilities and the allegations against Thomas Scott, Barnard was selected by Governor Arthur to urgently conduct a survey of King Island. Barnard and his 'party of exploration' proceeded to King Island on the *Prince Leopold* in late November 1826, and his survey findings were extolled in two editions of the *Hobart Town Gazette* (1826, 1827a, b). Governor Arthur wrote, 'I caused King's Island to be surveyed, and have the honor to transmit the report of Mr. Barnard, the Surveyor, with a map of the Island.' (Watson *et al.* 1914, vol. 6, p. 260).

From December 1826 to February 1827 Barnard spent 45 of his 69 days on the island exploring the country by land and water, surveying with a compass and 'Men under Command and direction' (Watson *et al.* 1914). In a letter

to Colonial Secretary Burnett in 1827, Acting Surveyor General Dumaresq records that modes of surveying performed by the Survey Department required that 'lines must actually be walked over with the Theodilite or Compass and chain' as 'Trigonometrical Survey…is almost impracticable in a new, wild and unsettled territory…' (Watson *et al.* 1914, vol. 6, p. 167). It is possible that the men under command and direction assisted Barnard with carrying a surveying chain. Although inconclusive, exploring the country by water may have involved surveys of the coastline and landscape features, had Barnard received training in hydrographic surveys as a navy midshipman (see Webb 2010). This is plausible as Barnard is believed to have later surveyed the coast at Circular Head (*Colonial Times and Tasmanian Advertiser* 1827a) and may have produced a Chart of Emu Bay (Barnard 1827).

It is also conceivable the coastline and landscape features of King Island may have been fully or partially mapped from previous surveys. It is worth acknowledging the Acting Surveyor General of New South Wales Charles Grimes, who mapped the majority of the island's coastline to a much higher level of detail and spatial accuracy in the summer of 1802–1803 and indicated locations of major waterbodies (Grimes 1802–1803). It appears less likely that surveys by Thomas Scott formed the basis of the map, given his duties and priorities at the time. Inspection of his surviving ephemera did not yield any sketches or references to King Island, other than a hand-copied extract of Barnard's Report (Scott, c.1820–1854).

When transmitting Barnard's Report and Plans, Dumaresq praised Barnard as having been, 'very persevering and very capable and patient of the fatigue and privation, unavoidable in the execution of such a Survey' and his account as, 'sensible, full and unexaggerated' (Watson *et al.* 1914, vol. 6, p. 262). Barnard's detailed report can be found in Series 3, Volume 6 of the Historical Records of Australia (Watson *et al.* 1914) and has previously been praised in literature. However, the accompanying plan he produced is absent from these records and for a long time appears to have been washed away in the tides of history.

Examination of the map available to NRE Tas revealed the use of linguistic terms and descriptions for some plants, which have otherwise not been recorded in that era (Backhouse 1834, 1835, 1836–1837, Wapstra *et al.* 2010, National Library of Australia, n.d.). Meticulous comparison of the map against Barnard's report successfully matched these personalised terms. This comparison shed a light onto his impressive recognition of subtle plant differences, such as differentiating between subspecies of what was likely satinwood *Nematolepis squamea*, or 'medicinal wood' as he described it. His manner of categorising unfamiliar plants was methodical to the extent that his descriptions can now be matched to their likely contemporary counterparts, despite there being no records of him receiving any formal botanical training.

A microfiche in the Records of the Colonial Office (National Library of Australia 2018) captures a despatch from Acting Surveyor General Dumaresq to Viscount Goderich, the then-Prime Minister of the United Kingdom, on 11 March 1827. Included are a summary letter, Barnard's survey report and an accompanying 'Descriptive Map of Rocks, Timber, Soil etc etc on King's Island, Tasmania' with a mapping scale of 'Three Quarters of an Inch to a Statute Mile'. This version of the map is nearly identical to the others discussed, and appears to have been formally copied by 'HS Hurst', the Honourable Secretary William Nevin Tatlow Hurst, Secretary for Lands 1825–1837. The original despatch containing this map is stored in the Records of the Colonial Office in the National Archives of the United Kingdom.

To conclude, all copies of this map can only be attributed to Barnard and are an important record of his 69 days on King Island in the summer of 1826–1827. Whilst balancing the emotions of men under his command, Barnard navigated multiple east-to-west transects through the core of the island's dense vegetation, grappling with 'bad wet scrub flats', 'many scorpions' and forests where, 'fern, cutting grass etc grows so thick, that it was difficult to get to a spit of earth' (fig. 1A). In addition to traversing the arduous vegetation and experiencing nausea from tasting bark for its medicinal properties (Watson *et al.* 1914), he also survived a violent strangling attempt by one of the men – arising from a dispute over the spirits ration (*Colonial Times and Tasmanian Advertiser* 1827b, c, Bell 2020). The latter was hauled back to Van Diemen's Land and sentenced to five years at the Macquarie Island Penal Station (*Colonial Times and Tasmanian Advertiser* 1827b, c, Bell 2020). Although it is believed Barnard applied for work as a surveyor upon his return, his application was unsuccessful (Watson *et al.* 1914, Bell 2020). This could be considered a great pity, as his survey of King Island truly captured information in a way that remains of immense relevance to present-day GIS interpretation and vegetation classification.

ACKNOWLEDGEMENTS

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APPENDIX

Three copies of the map have been identified:

- Department of Natural Resources and Environment Tasmania high-resolution scan of the original plan identified as: *Map – King Island 15 – plan of island from Scotts survey.* Item Number AF396/1/825, Lands and Surveys Department, Tasmania.
- Copy on tracing paper: Scott, Mr. (1850). *King Island (1850–1880).* UTAS Special & Rare Collections (Royal Society Map Collection RS Mp/14), The Royal Society of Tasmania, Australia.
- Microfiche 'copied from dyeline of map probably drawn between 1825 and 1826': *Kings Island: from Scotts' survey. [microform].* Libraries Australia ID 9578670, State Library of New South Wales.

NEW PERSPECTIVES ON THE CENOZOIC HISTORY OF THE TAMAR VALLEY AND LAUNCESTON GORGE

by Robert E Cotton

(with five figures, one plate and one appendix)

Cotton, RE (2025). New perspectives on the Cenozoic history of the Tamar Valley and Launceston Gorge. *Papers and Proceedings of the Royal Society of Tasmania*. 159: 27–37. ISSN: 0080-4703. Email: rec.minap@outlook.com

The Tamar Rift Valley carries evidence of an often-turbulent history during the Cenozoic period. For this research the principal rock units: dolerite, sediments, basalts (vents and flows) and conglomerates, interacting over the past 70 million years were computer modelled. Reconstructions showed that the Longford Basin was integral to the evolution of today's Tamar Valley, so were extended over the north of that basin. The main outcomes were:

The Tamar Graben and Longford Basin filled with sediments to 140 m elevation in a lake (Lake Tamar–Longford) upstream of a wall-to-wall volcanic dam across the Tamar Rift Valley. This dam coincided approximately with the current Batman Highway.

Sediments of the Longford Basin sector of the lake were subsequently raised from 140 m to 190 m elevation, upstream of a second volcanic dam based on the 140-m surface near Evandale in the Tamar Valley. This sector was separated from the Tamar by a five-km-wide dolerite horst, minimum height 190 m above sea level.

The lake (Lake Longford) overflowed along fractures in the dolerite, commencing near future Hadspen at 190 m, across the Trevallyn Fault near Launceston. The resulting high energy waterfall, draining the new Lake Longford, retreated approximately 15 km back through columnar dolerite to Hadspen, forming the Cataract Gorge.

Key Words: Tamar, Cenozoic, Longford, volcanic dam, Cataract, waterfall, retreat.

INTRODUCTION

Maps of the northern coastline of Tasmania show, east of centre, a north-northwest-trending, parallel-sided estuary extending inland for some 50 km as far as the city of Launceston. The structure controlling the linearity of the estuary is well-recognised as a rift valley averaging four to five kilometres in width and extending beyond Launceston for another 20 or more kilometres (fig. 1) where it opens into the broad Longford Basin to the south and west (Matthews 1983, Direen & Leaman 2018).

At several points in and near the original trough, volcanic vents opened and erupted basaltic lavas, which the geologist FL Sutherland, mapped and later obtained age data for (Sutherland 1968, 1969; Sutherland *et al*. 2006). The Sutherland *et al.* (2006) paper establishes valuable reconciliation between those dates and spore biozones as used in Bass Strait oil and gas exploration. Sutherland, however, did not have the advantage of access to subsequent detailed (1:25,000) mapping of the basins and surrounds by geologists from Mineral Resources Tasmania.

This work owes much to Sutherland's papers and thesis. It has involved three-dimensional (3D) computer modelling to extend Sutherland's manual structure contouring of the base of the basalts to include the trough sediments and marginal conglomerates. From this base, 62 geological models were prepared to show the evolution of the Tamar and Longford basins spanning about 70 million years. This process offers new perspectives on the evolution of the Cataract Gorge, a unique natural asset on the edge of the city of Launceston.

METHODOLOGY

The research objective was to understand the evolution of the Tamar Valley landscape, including the Cataract Gorge, between about 100 Ma (million years ago) and the present day. The approach chosen was to model the contributing geological events at time intervals of three to four million years for gradual processes and about 0.5 million years for active processes. Continuity and coherence between intervals needed to be maintained, consistent with evidence from the data sources.

The study area, situated in northern Tasmania, covers over 4,000 sq km of the Tamar and North Midland regions, bounded by the central northern coast, the Eastern Tiers and Western Tiers; and the townships of Poatina and Nile to the south. The primary data sources were:

Mapping from Mineral Resources Tasmania (MRT) formed the primary geological data set covering 2,650 sq km of the central project area. These 1:25,000 maps were produced between the years 2004 and 2011.

The topographic database included parts of the Dorset, George Town, Latrobe, Launceston, Meander, Northern Midlands and West Tamar 10 m contour coverages.

Subsurface data from the MRT Drillhole database assisted computer modelling. This included mainly lithological logs but also geochemical analyses, and downhole geophysical records.

Research literature provided context and support for the interpretation of geological data. Data fundamental to sequencing were basalt ages given by Sutherland *et al.* (2006). Photographic records from MRT and Google Earth GIS images, assisted interpretation.

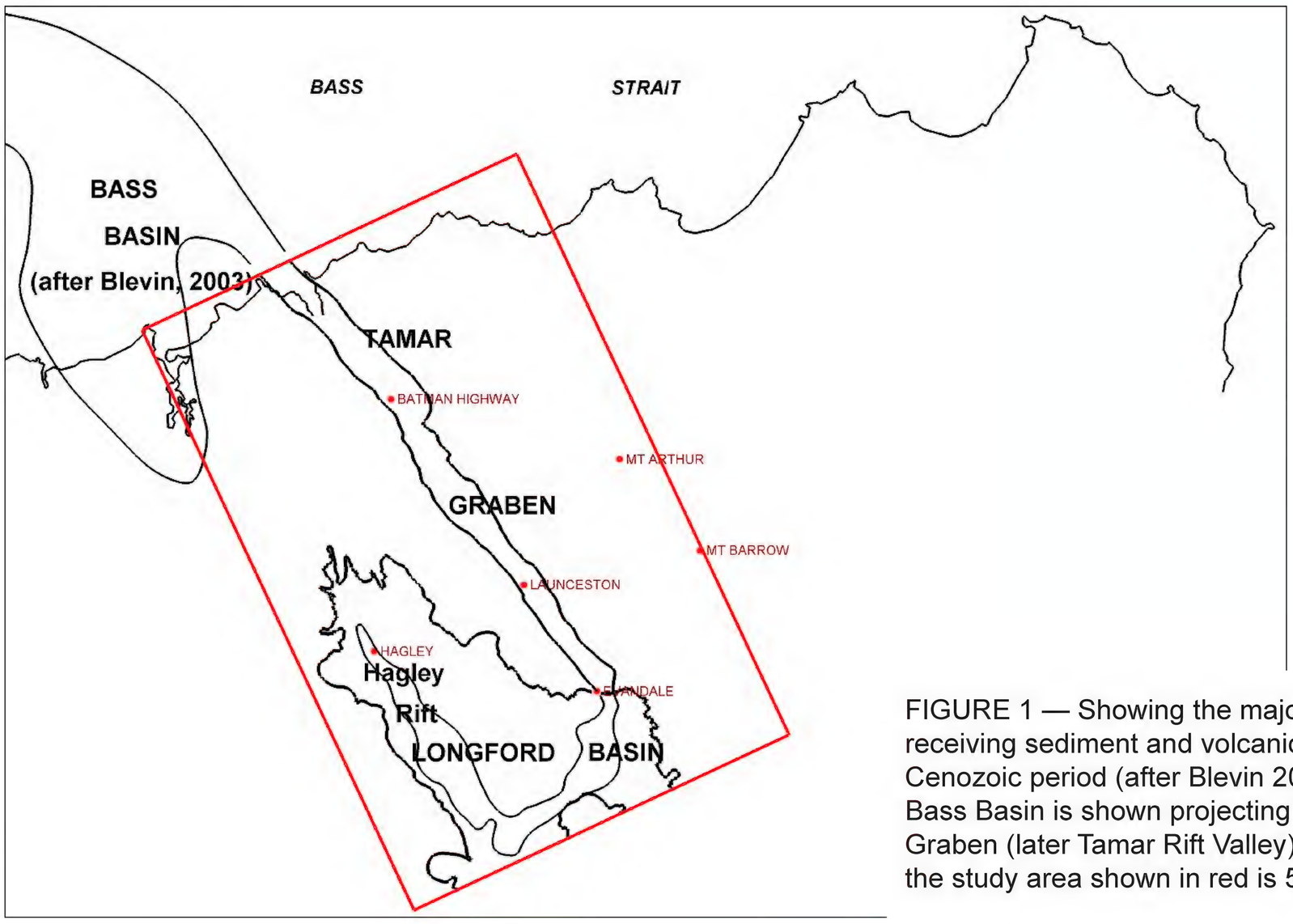

FIGURE 1 — Showing the major structures receiving sediment and volcanics during the Cenozoic period (after Blevin 2003). The Bass Basin is shown projecting into the Tamar Graben (later Tamar Rift Valley). The width of the study area shown in red is 50 km.

Field visits between 2020 and 2024 assisted interpretation of mapped geology.

PROCEDURE

Ten-metre contours for the project area were obtained by merging regional data sets into a single digital terrain model (DTM) of the project's modern surface. Individual outcrops were digitised. About half of these were grouped in sets according to rock type. With contours overlaid on the 1:25,000 geology, structure contours of rock contacts were prepared. The critical contacts were: Cenozoic sediments against dolerite, basalts against dolerite, and conglomerates against dolerite. By projecting structure contours between outcrops, pre-sedimentation contours of the walls and floor of the Tamar Graben and Longford Basin were interpolated and a pre-sedimentation DTM prepared. Much of the DTM is shown in figure 2 and figure 3 (containing sediment).

The two basins were host to a variety of fills: water, sediments, volcanic vents, basalts and conglomerates. Positive features such as the volcanic dams were modelled by increasing vent elevations and extending basalt flows consistent with the mapping. Negative features such as valley erosion within sediments required detailed shaping. 3D arrays (65 workplaces in age sequence) were populated with multiple geological entities in these categories utilising 3D geological software. Four to six screenshots of each array were made, two of which showed the entire project area from north and south. Age intervals chosen between arrays allowed conversion to video. The need for geological continuity, and for commentary on each screenshot, facilitated this paper.

For the purposes of this study, it was assumed that linear age interpolation could be made between array ages derived from (a) Sutherland's basalt ages, (b) best estimates from literature, and (c) the Time-Space Diagram for Tasmania (Seymour & Calver 1998). To avoid unnecessary complication, for the purposes of modelling all pre-Cenozoic rocks in the project area were treated as 'dolerite'.

To clarify the terms used in the paper: the Tamar Graben is a trough structure made in response to local stretching of the Earth's north Tasmanian crust. It is about five km wide and at least 50 km long made by sinking crustal rocks between two sub-parallel sets of fault lines. This process is referred to as 'rifting'.

The rock floor of the graben varies from about 40 m above present sea level near Launceston to about 200 m below sea level nearer to Bass Strait. The graben became a repository for silts and sands over time, filling the role of a sedimentary basin, and is termed the Tamar Basin. The modern landscape is strongly influenced by the ancient graben. The graben underpinning of the landscape is recognised by calling the Tamar Valley a 'rift valley'.

Pre-Cenozoic: the Tamar Graben and Longford Basin

In the east of the Gondwana Supercontinent, including future Tasmania, sheet-like expanses of mudstones and sandstones were deposited in shallow seas. In places these carry evidence of the existence of glaciers (Corbett 2019, p. 44). They were deposited almost continuously over 100 million years between 310 and 210 Ma (Seymour & Calver 1998) and still cover much of eastern Tasmania. Gondwana started to break up around 200 Ma.

The way molten dolerite masses forced their way flatly into these sediments of eastern Tasmania (with related rocks extending across Antarctica into South Africa) is well described by Corbett (2019, p. 114). The multiple

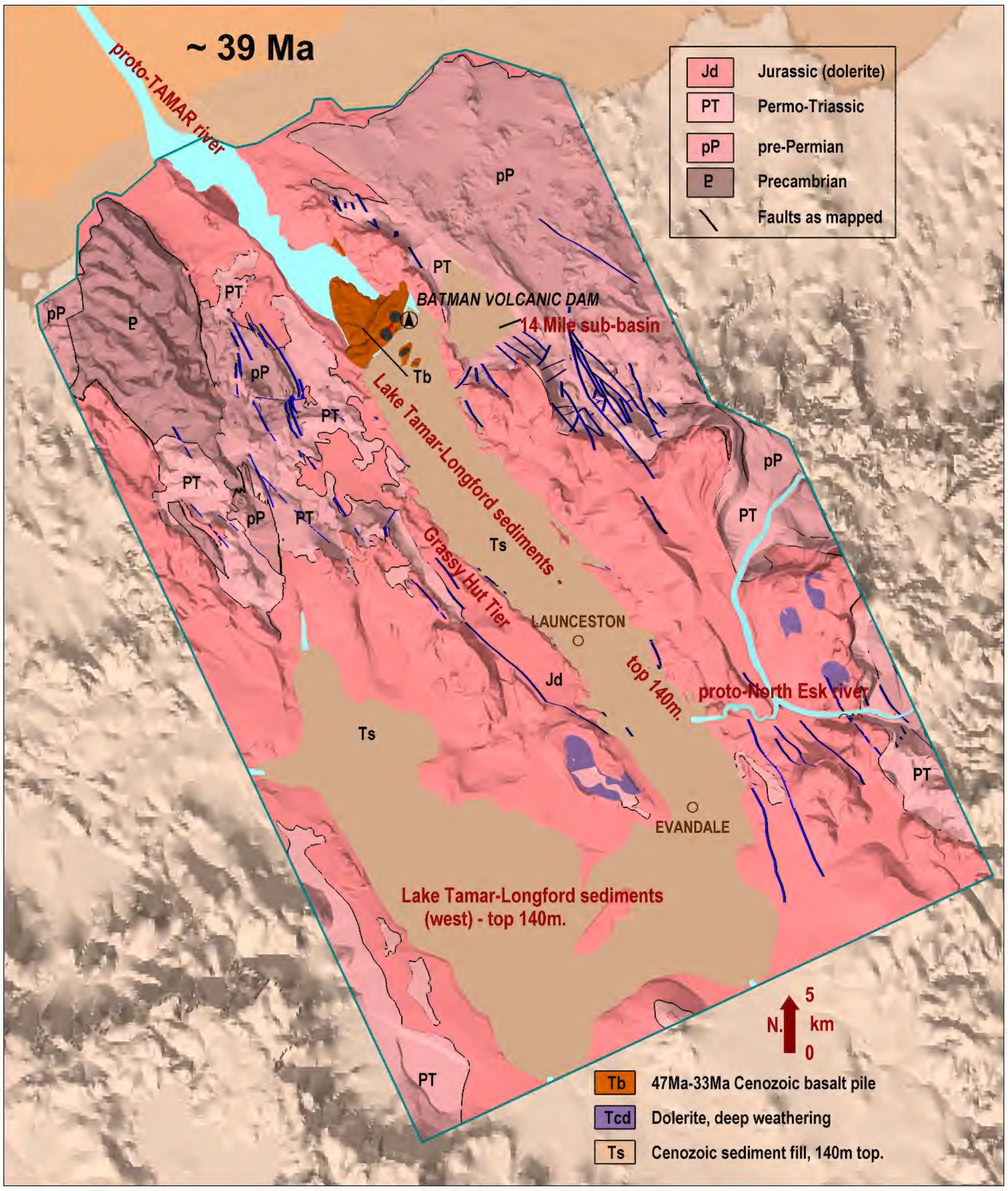

FIGURE 2 — Cenozoic sediments deposited in Lake Tamar–Longford extend upstream from the barrier created by the Batman volcanic dam, named for the Batman Bridge area.

intrusions happened in pulses between 180 and 167 Ma when Tasmania was at approximately 65° south latitude.

The deep Bass Basin in Bass Strait was initiated in the latest Jurassic–early Cretaceous period (150–130 Ma) due to crustal extension related to pre-breakup rifting between Australia and Antarctica (Cummings *et al.* 2004). Between about 125 and 100 Ma, Australia and Antarctica together became the last remnant of Gondwana following the departure of India (White *et al.* 2013). Rifting, but not spreading, between Australia and Antarctica began off southwest Western Australia about 165 Ma and extended slowly east until about 80 Ma (White *et al.* 2013). If the rifting line had continued east through Bass Strait, Tasmania would have remained linked with Antarctica while Southern Ocean spreading took mainland Australia north.

Eighty Ma saw a breakup between the two continents, coinciding with spreading in the Tasman Sea. The new spreading away from Antarctica continued very slowly until 45 Ma. Major transform faulting off the Tasmanian west coast released Australia and Tasmania to move rapidly north (25° latitude in 45 million years).

After the breakup, Bass Basin rifting continued to propagate southward resulting in the opening of the Tamar Graben in the latest Cretaceous, at approximately 75 Ma (fig. 1). The Longford Basin had begun to form in the mid-Jurassic, possibly contemporaneous with the massive dolerite intrusion event. It is divided into western and eastern sectors by a buried north–south dolerite ridge. A deep rift (to 800 m below sea level) developed south of future Hagley within the Longford Basin.

The rifting underpinning the Tamar Valley is still apparent today in vertical steps of 50–100 m or more from below sea level in the Tamar Estuary across to the crests of Mount Arthur, Mount Barrow and Ben Lomond above 1,200 m elevation. The west wall of the valley is also stepped by faults to crests 300 m above sea level in the up-faulted (horst) block separating the Tamar Basin from the Longford Basin, the Grassy Hut Tier (figs 2, 3).

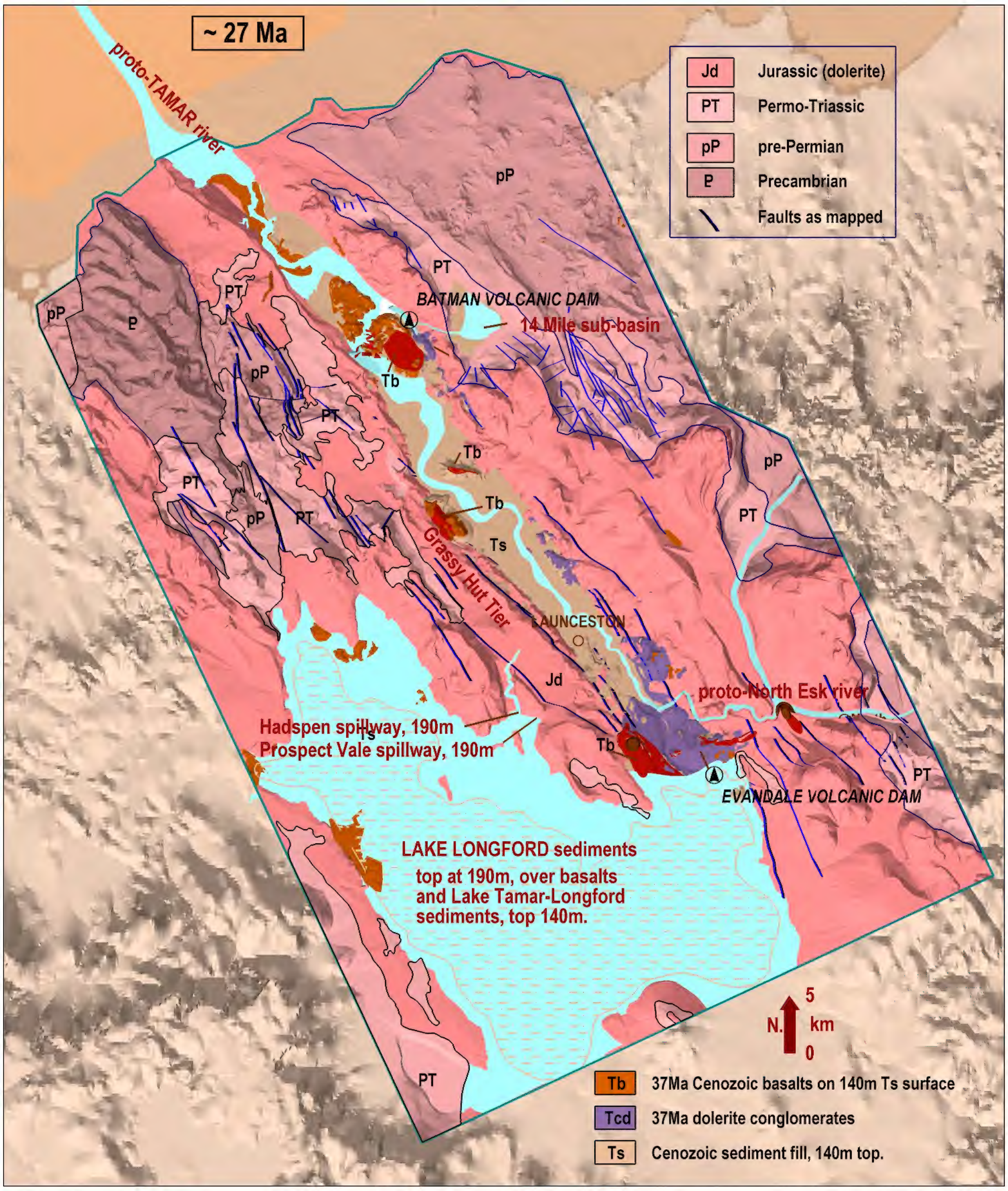

FIGURE 3 — Water and sediments of the new Lake Longford (blue) have accumulated upstream of the Evandale volcanic dam and risen to an elevation of 190 m and start to overflow the dolerite horst (Grassy Hut Tier) separating it from the Tamar Rift Valley. The sediments upstream of the earlier Batman volcanic dam are reduced in width by erosion (compare fig. 2).

Cenozoic sediments

Sedimentation began within the Tamar Graben about 70 Ma and continued until at least the dated Georgetown basalts at 25 Ma (Sutherland *et al.* 2006). Sedimentation continued after this time but was significantly broader than the Tamar Graben as defined. This was about the time when sedimentation transitional to marine in the Bass Basin became open marine (Cummings *et al.* 2004, p. 139). The first seawater entered Bass Strait west to east over saddles in the King Island rise. It appears it did not enter the Tamar Graben as all sediments there are freshwater. Either the graben was above sea level, or barriers to marine incursion existed.

Sedimentation in the Longford Basin, including filling the deep Hagley Rift (fig. 1), was effectively continuous from 65 to 20 Ma (Corbett 2021). Sediments in both basins are mainly lacustrine sands, silts and clays. However, higher energy sediments are frequent. These include coarse sands, gravels and conglomerates, often with pebbles or cobbles from distant sources. These features suggest that the basins were fed by fast-running streams carrying their sediment loads well offshore.

The proto-Kanamaluka/River Tamar probably had a similar catchment area to the present North Esk, South Esk and Macquarie rivers. Fault scarps, affecting mainly dolerites, were in retreat and the debris was being carried into the Tamar and Longford basins, thence into Bass Strait where the Bass Basin was in active subsidence.

Cenozoic volcanics – the first volcanic dam and Lake Tamar–Longford (140 m)

The oldest dated volcanic vents intruding the Tamar Basin were in the vicinity of the Batman Highway, 30 km north-northwest of Launceston. When these started erupting basaltic lavas, the Tamar Graben (in dolerite) was complete

and the periodic earthquakes generated by the faulting and rifting of dolerite had given way to seismicity associated with volcanism.

After a period of volcanic activity, the first lavas flowed out over the earliest (65–50 Ma) Cenozoic sediments deposited in the Tamar Graben. In this area, a sample of the Rowella Basalt, 80 m below sea level in a drill hole, was dated at 47 Ma (Sutherland *et al.* 2006). A sample from a higher level of the pile gave an age of 33 Ma suggesting at least 14 million years of volcanism. Over time the lavas built up, layer on layer, gradually spreading wider. A volcanic pile started to accumulate as more vents opened south of the future Batman Highway. Continued flows down the flanks of the pile started to meet the dolerite walls of the valley. These built up until basalt extended wall to wall. Water flowing to Bass Strait in the new valley had the effect of cooling the molten lavas on the upstream (Launceston) side, effectively making a wall which dammed the stream and increased its depth as the barrier built higher. Its position roughly coincided with the present Batman Highway. Although in places the basalts reached higher, the water retention height of the dam was finally 140 m above current sea level. The new dam was probably completed prior to the marine transgression marked by the Demons Bluff sequence in Bass Strait at 43–44 Ma.

However, with the advent of the Batman volcanic dam, water and sediments steadily accumulated upstream of the dam. This new lake initially stretched from the dam wall at the Batman Highway to about 10–15 km southeast of future Evandale. This lake has been described as Lake Tamar (Carey 1947, p. 37; Manchester 2010, p. 13). The parallel deep Hagley Rift to the west also filled with Cenozoic sands and clays. When the rift filled, its sediments extended over the floor of the Longford Basin commencing about 65 Ma. The latter is referred to as Lake Cressy by Carey (Carey 1947) and more recently as the Longford Basin or Lake Longford by Matthews (Matthews 1983, p. 151).

Initially the two lakes were separated by a fault-bounded horst or dolerite ridge which connected the Grassy Hut Tier and Devon Hills dolerite, two km west of Evandale, to the Hummocky Hills dolerite near Epping (Corbett *et al.* 2014, p. 444 & fig. 9.29). Cenozoic sediments accumulated on either side of the ridge (Matthews 1983, fig. 2). The low point of the dolerite ridge was a saddle 80–90 m above sea level, now buried.

As the two lakes grew deeper, this saddle eventually allowed water and sediment to equalise between Lake Tamar and Lake Longford (about 41.5 Ma), effectively becoming a single Lake Tamar–Longford. Sediment accumulated across the entire combined area until the 140 m retention level of the Batman volcanic dam was reached. This combined lake area thus extended through future Launceston, past Evandale, then southwest beyond Cressy and Longford (fig. 2).

Another extension to Lake Tamar occurred when the lake reached 80 m above sea level, and water and sediment crossed a spillway east of East Arm into a small triangular sub-basin now drained by Fourteen Mile Creek. The total lake sediment surface is shaded light brown in figure 2.

Meanwhile, dolerites of the highlands east and west of the Tamar Basin (ex-graben) were slowly weathering deeper (fig. 2). Multiple fractures resulting from the long faulting and rifting episodes assisted penetration by water. The weathering produced a mantle of structurally weak dolerite clays (Mazengarb 2005, p. 13) containing residual dolerite boulders (Slee *et al.* 2017, p. 3). At this stage, frequent earthquakes were related to volcanism rather than faulting. These factors led to the initiation of gradual mass movement of dolerite conglomerates down slopes towards the proto-Kanamaluka/River Tamar (Carey 1947, Saroli *et al.* 2021).

Reduction of the Batman volcanic dam

The Batman volcanic dam was in place long enough for the Tamar-Longford basin to fill with sediments but also several metres' depth of water. Leakage under pressure from the lake along columnar jointing and fractures, assisted deep weathering of the blocking basalts, reducing the integrity of the dam. The active seismicity was also a factor. Possibly related to a particularly strong earth tremor, the dam gave way catastrophically, focussed on the weak contact with dolerite north and south of the present Batman Bridge. The lake-fed torrent and debris scoured a new valley opposite the breach, filled now by the Devils Elbow backwater. When the torrent ran out of momentum up-slope it returned to the present easterly course of Kanamaluka/Tamar River (fig. 3).

More significantly, large volumes of unconsolidated Cenozoic sediments were undercut and sluiced downstream. This initiated the re-birth of the proto-Kanamaluka/River Tamar and the start of the riverine valley-in-valley erosion responsible for revealing the present Tamar landforms. Strong evidence for this event comes from interesting work by Calver (2011). As a result of undercutting of sediments, substantial blocks of basalt broke off and were dislocated down slope. Calver's measurements show that some blocks rotated in the process, one rotation of 50° ± 30° testifying to the violence of the event. Such dislocations are clustered in the vicinity of Whirlpool Reach near Batman Bridge. Whirlpool Reach itself (30 m deep) is likely to be the result of related scouring.

By the time Lake Tamar–Longford drained completely, a new river system started to etch into the 140-metre Cenozoic surface (about 37.2–37.1 Ma). The entry points for these rivers into the Longford Basin were probably much as they are today (fig. 2). They converged into a single stream (proto-Kanamaluka/River Tamar) which ran east above the buried saddle, entered the Tamar Graben near future Evandale, then flowed north to landlocked future Bass Strait. Its bed was around the 110 m level within banks still at 140 m. It then continued north, cutting into the 140-m sediment surface of the Tamar Basin (Carey 1947, p. 42; Nicolls 1960, p. 6).

At a stage when the proto-Kanamaluka/River Tamar was flowing at about 90–80 m above present sea level, it was flowing east of future Windermere and the 140-m sediment surface was continuous from Windermere to Grindelwald. The Grindelwald vents erupted about 37

Ma (Sutherland *et al.* 2006) and basalt spread east over the surface almost to the river. At about 80 m elevation the proto-Kanamaluka/River Tamar encountered resistant bedrock and a course change to the west resulted, separating Grindelwald and Windermere and leaving the latter as a mesa of sediments capped at 140 m by the Grindelwald basalt (Macdonald 1998).

The collapse of the Batman volcanic dam allowed a strong erosion face to develop upstream in the weakly consolidated Cenozoic lake sediments. A V-shaped valley in sediments started migrating south from the breached volcanic dam. Although the erosion was strong, it was not complete. Where protected by basalt and/or dolerite conglomerate, the 140-m lake top was preserved in mesa-like landforms at Murphys Hill, Grindelwald, Windermere, Airport and from the water tunnel north of Evandale (plate 1) around the 140-m bench around to Whites Hill.

At future Launceston the erosion face divided, leaving behind the modern High Street ridge landform. Its current high point is only 20–30 m below the original Lake Tamar–Longford surface.

Cenozoic volcanics – the second volcanic dam and Lake Longford (190 m)

By the time the proto-Tamar had lowered its bed to an elevation of about 110 m relative to the 140-m surface at Evandale, another volcanic vent opened, this time just north of the future airport. This is now a rather unimpressive hill, Cocked Hat Hill, but its top is still above 200 m elevation. The hill itself was an active vent and the basalt has been dated at 37 Ma (Sutherland *et al.* 2006). The Cocked Hat Hill basalts flowed out covering a mass-movement dolerite conglomerate deposited on the Airport bench of the 140-m surface. The flows continued down-slope towards the banks of the new channel being cut by the proto-Kanamaluka/River Tamar at 110 m elevation (fig. 3).

Similar events were taking place 12 km northeast of Evandale. The Stromboli vent opened and basalt filled a linear valley which faulting had made in the dolerite surface. The base of the basalt here was at about 300 m elevation, about 150 m above the local top of the Tamar Basin sediments. The seismicity associated with the Cocked Hat Hill and Stromboli vents assisted the mobilisation of dolerite conglomerate lobes towards the proto-Kanamaluka/River Tamar (fig. 3). In the White Hills area on the east side there was interlayering and intermixing of basalt with dolerite conglomerates (Corbett *et al.* 2014, p. 443) above Rose Rivulet (Sutherland *et al.* 2006, p. 51). A stratigraphic diamond core hole put down by the Tasmania Department of Mines, WH-DH4, intersected dolerite conglomerate with frequent basalt inclusions between 198 m and 161 m elevation. This was underlain by a basalt flow between 161 m and 156 m elevation. Below this were two metres of conglomerate then fine silts and clays to the end of the hole.

PLATE 1 — A remarkable photo taken by MRT geologists near Evandale showing the flat top of Lake Tamar–Longford sediments in the lower part of the tunnel, covered by a darker basalt flow. The contact is at 140 m elevation. The source of the basalt was a volcanic vent (now Cocked Hat Hill) just north of Launceston Airport.

At a depth of 13 m in this hole, basalt was noted welded to dolerite/basalt conglomerate. This testifies to the synchronicity of the volcanic and conglomerate events. The basalt and conglomerate masses, generally separate but close in time (37 Ma), converged on the 140-m surface towards the banks of the proto-Kanamaluka/River Tamar (fig. 3). The arrival of further basalt from east and west, and conglomerate from east and west, eventually blocked the stream. It filled the channel of the proto-Kanamaluka/River Tamar from its bed at 110 m to above the 140 m level for two or three kms. Further fill continued to raise the dam edifice to 190 m retention level and above. The vents of the east and west basalts were above this level and dolerite conglomerates were available well above these levels in both areas. This became the second volcanic dam to block the Tamar Valley but with its starting base 140 m higher.

The effect of the Evandale barrier was for water and sediment to start filling the upstream proto-Kanamaluka/River Tamar valley. This new lake expanded over the 140-m western surface of Lake Tamar–Longford and eventually accumulated a further 50 m of sediments.

Some unpublished accounts have the South Esk River immediately diverted by this blockage to the entrance to the Gorge at Hadspen. These accounts assume that the present Gorge entrance level (135–140 m) has not changed over 37 million years. This concept would require another agency to excavate a gorge through the dolerite horst ahead of the arrival of the diverted South Esk River. These difficulties are removed by the high barrier created by the Evandale volcanic dam adding 50 m elevation to the 140-m surface. This barrier in turn gave a 190 m elevation to the top of Lake Longford and the Longford Basin sedimentary fill (Matthews 1983, fig. 2: Longford Basin Geology). This extensive lake provided abundant water to cut the Cataract Gorge.

With the Evandale Dam in place and Lake Longford filling, the Tamar Valley was deprived of the waters of the proto-Kanamaluka/River Tamar leaving only the flow of the proto-North Esk River. Accordingly, erosion in the valley was much reduced. At this stage relationships are as indicated in figure 3.

Gorge initiation at 190 m

Four kilometres east of the Cataract Gorge is evidence of a second waterway which had the potential to cut a gorge through the high dolerite into the Tamar Valley. On the west side of Prospect Vale is a pre-Cenozoic saddle in the dolerite horst separating the Longford Basin from the Tamar Valley (fig. 4). Prospect Vale itself is on a domed sediment outwash fan delivered over the saddle when the Cenozoic Lake Longford was at its maximum elevation.

The mapped level of Lake Longford Cenozoic sediments at the saddle is currently 180 m (post-erosion) with the dolerite saddle a little higher. The fan outwash delivered over the saddle is 'partly consolidated clay, silt and clayey sand with some iron oxide-cemented layers and concretions, some leaf fossils' (Prospect 1:25,000 geological map legend).

At Prospect Vale, implications are that water and sediment were delivered from Lake Longford over the dolerite saddle

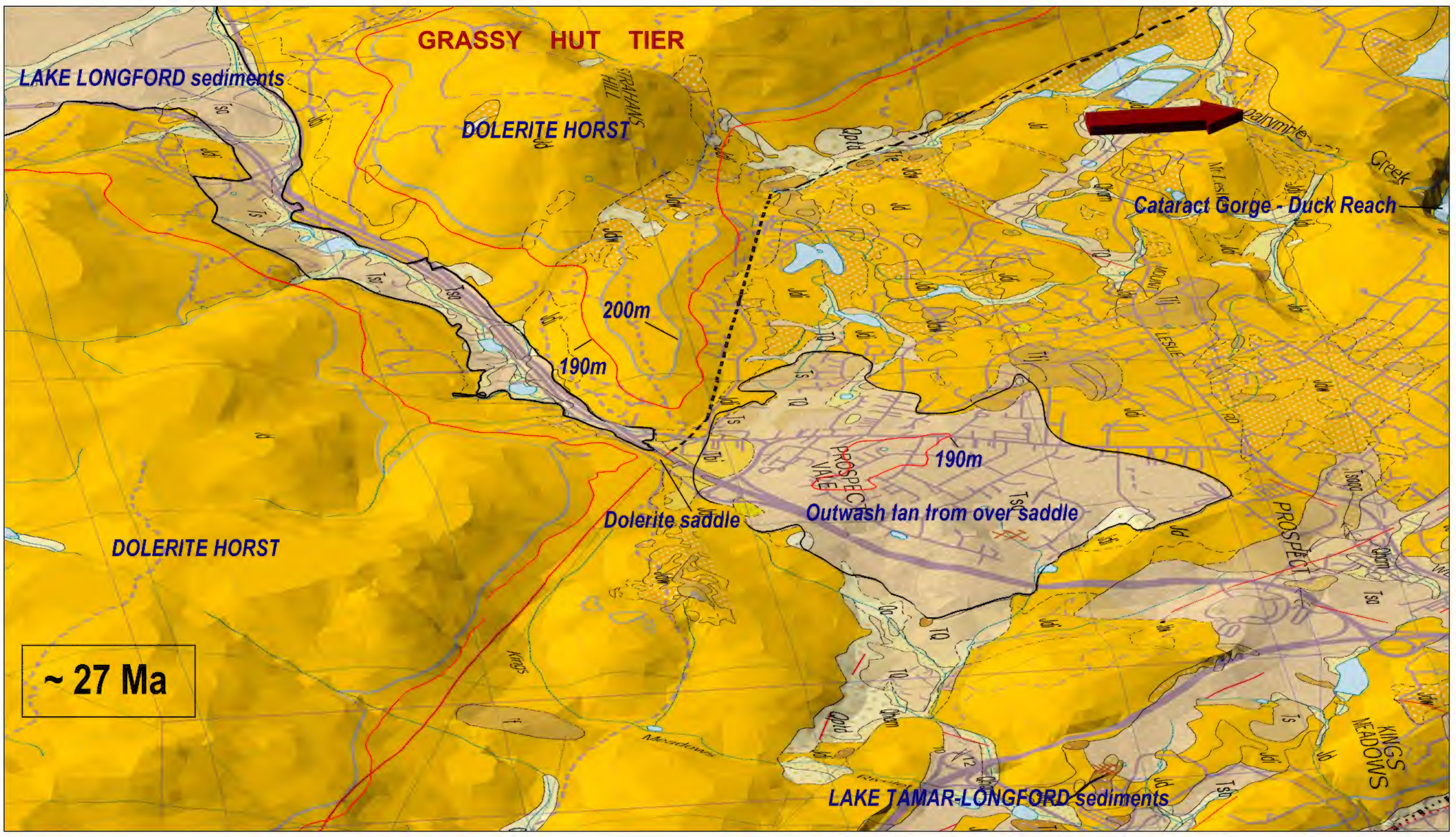

FIGURE 4 — Looking west. The Bass Highway traverses a dolerite saddle between the Tamar and the Longford drainages, which here are only 150 m apart. Discharge events from Lake Longford towards the Tamar (left to right in the figure) created a domed outwash fan, now Prospect Vale, on a near-flat dolerite surface at 180 m elevation. This spillway failed when the Cataract spillway dominated. North arrow is 0.5-km-long. Prospect 1:25,000 Geological map

when the saddle was 15 m higher (190 m elevation) and spread out as a fan on a perched 180-m dolerite surface on the Tamar side of the saddle (fig. 4). On the Prospect 1:25,000 scale geological map and in the contours, there is no evidence of the Lake Longford water flow etching the top of the saddle. Overflow of the lake has happened here but it appears to have been a quiet event, perhaps at the very top of the lake rise. Meanwhile lake overflow (proto-Cataract River) was making its way slowly along about 15 km of dolerite fractures towards the west edge of the Tamar Graben. It became a more successful spillway than the Prospect Vale saddle where fault-related conduits were not present. The spillway became a river capable of excavating the Cataract Gorge, and the leakage of lake water and sediment over the saddle to Prospect Vale ceased.

The implication is that the Prospect Vale discharges could not have happened if all water and sediments upstream of the Evandale volcanic dam were not at or close to 190 m elevation. This evidence of limited lake spill right at the top of its rise confirms 190 m ± as the elevation of the entire Lake Longford, from Hadspen west to the Western Tiers and from Evandale south to Epping Forest and surrounds. This is shown graphically in Matthews (1983, fig. 3) by the blue shaded contact between Cenozoic sediments and dolerite basement around the basin.

To test this, elevations of points on Matthews' (1983) map of the contact between Cenozoic sediments and pre-Cenozoic basement were identified from overlaid current topographic contours. These fall in the 190–210 m range around much of the Longford Basin perimeter. However, in the southeast of the basin, just east of Campbell Town, sediments locally ramp down from above 230 m, through 210 m to 190 m and represent a major sediment input to the basin. Three locations in the western margin also show sediment sources at 230 m or more. These are limited in width, marking former watercourses into the basin from the Western Tiers.

Overall, there is considerable geomorphic evidence for the Northern Midlands plains being the residual of a once-continuous 190 m ± 10 m Cenozoic sediment surface upstream of the Evandale volcanic dam (figs 3, 5). A corollary is that the modern courses of all the Northern Midlands rivers, except for the North Esk River, commenced at an elevation of 190 m and have eroded down to their present elevations of 140–150 m. In places this riverine erosion has exhumed the tops of basalt flows resting on the buried 140-m surface.

Excavation of Cataract Gorge

The new Lake Longford filled with water and sediment upstream of the Evandale barrier. Sediments attributable to the Evandale barrier are shown in yellow on the cross-section of figure 5. Near its top at 190 m elevation, a small arm of the lake bypassed future Hadspen and entered the fracture system of the Grassy Hut Tier (dolerite horst) initially as a narrow backwater (fig. 3). Its course was northerly until it intercepted a fracture trending northwest–southeast at a slightly lower elevation. Enlargement of this spillway confirmed capture of the new Lake Longford by a Tamar-flowing watercourse. This watercourse led the lake waters to the dolerite fault scarp (Trevallyn Fault) 100 m or more above the site of the future Kings Bridge resulting in a high-energy waterfall.

Increasing energy of the 100-m-high waterfall resulted in a 15-m-deep plunge pool under what is now the Kings and West Tamar bridges. As the lake spillway enlarged, continuously increasing volumes of water undercut the tall dolerite columns. Slowly the waterfall retreated upstream, carving out the steep-sided gorge familiar today.

The First Basin is different in character to the simple picture of a migrating waterfall. From the bridges to the First Basin the course is simple and linear. Broken dolerite columns remain in the bed of the Cataract which were undercut by the ancient waterfall. At the First Basin the dolerite shows frequent vertical fractures in addition to the normal columnar partings. This relates to an intersecting fault system (Manchester 2010, p. 14). There the erosive power of the waterfall was spread and its progress delayed until the easier erosion was complete over a broad area.

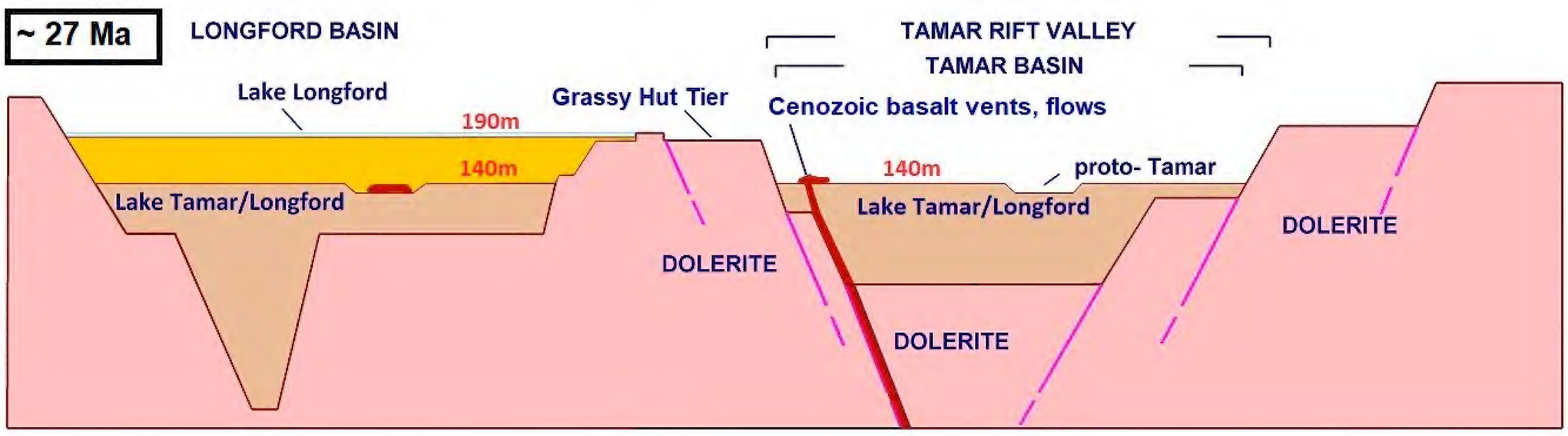

FIGURE 5 — Diagrammatic cross-section looking north shows Cenozoic sediments of Lake Tamar–Longford as in figures 2 and 3 (light brown) upstream of the Batman volcanic dam, with superimposed Lake Longford sediments (yellow) deposited upstream of the Evandale volcanic dam. This is the situation at the start of the Cataract Gorge spillway.

Eventually the new basin was surrounded by normal resistant dolerite and the water was forced to resume erosion confined to a single faulted exit structure.

Dolerite, being a resistant rock, the rate of progress was slow, perhaps the width of three to four dolerite columns (4–5 m) per 1,000 years on average, the height of the waterfall gradually reducing upstream. At this rate the excavation of Cataract Gorge would have required about three to four million years. The flow of water feeding the Cataract waterfall eventually started to lower the level of water in Lake Longford until the lake drained completely and exposed the lake's 190-m Cenozoic sedimentary surface.

The proto-South Esk, Macquarie and Meander rivers and tributaries etched new courses in the exposed surface. The river courses were modified by the variable resistance of lower surfaces, as the rivers deepened. The new focus of all drainages (except the North Esk River) was the Gorge entry near future Hadspen. Thus, the Evandale volcanic dam did more than divert the South Esk River, it diverted all the rivers of the catchment, via Lake Longford. These courses were essentially those we see today.

Approximately 30 cubic km of Cenozoic sands, silts and clays (which filled to near the level of the current Grindelwald Resort) have been eroded out of the Tamar Rift Valley following the catastrophic collapse of the Batman Dam and laid down in a new repository, the Bass Basin. The remaining valley-in-valley topography has been further modified by the incursion of the sea, creating the modern estuary.

By 20 Ma the stepped dolerite fault blocks of the region were in place and stable. The earthquakes and fires of the volcanic vents which dammed the proto-Kanamaluka/River Tamar in two places were long extinguished. Only the resistant basalts and their sedimentary legacy, which have survived the millennia, remained. The baking Earth temperatures of the Eocene Optimum appear not to have left their mark on the Tamar Valley. Spores and leaf impressions in the remaining Cenozoic clays testify to millions of years of fertility. If we move forward to the LGM (Last Glacial Maximum) only 20,000 years ago, Bass Strait was again dry apart from the freshwater Lake Bass in its centre, still receiving water from the Kanamaluka/River Tamar.

CONCLUSIONS

Pre-Cenozoic events summarised in this paper, are fully described in the literature. These include Jurassic dolerite intrusion, Antarctic breakup and related rifting of the pre-Cenozoic basement, creating the Bass Basin, the Tamar Graben and the Longford Basin, including the deeper rift south of Hagley. Early sedimentation in the pre-Cenozoic Tamar Basin was then accompanied by periodic eruption of basaltic lavas from vents; first in the Batman Highway area, then in the Grindelwald, Cocked Hat Hill and Stromboli areas. The Batman basalts formed a wall-to-wall volcanic dam from below sea level to a retention height of 140 m.

Cenozoic silting upstream of this dam created an essentially flat surface back through future Evandale and across to the Western Tiers at 140 m elevation. With the demolition of the Batman Dam by water erosion, a V-shaped valley head migrated south by riverine erosion of the loosely compacted Cenozoic sediments. Near Evandale, two new volcanic vents spread flows on the 140-m surface. These basalt flows, assisted by the arrival of moving masses of dolerite conglomerates triggered by volcanic seismicity, created a second massive volcanic dam at future Evandale. This new dam rose to a retention elevation of 190 m across the valley, leaving the proto-North Esk River as the only water to supply the lower reaches of the proto-Kanamaluka/River Tamar.

A new lake formed upstream of the Evandale Dam. The proto-South Esk River, the Macquarie and the Meander river systems filled the Longford Basin to 190 m, the height of the Evandale Dam. At this level the now mature Lake Longford found an escape route, utilising fractures, across the dolerite horst separating it from the Tamar. An ensuing 100-m waterfall at the future Kings Bridge retreated along the fractures excavating the Cataract Gorge. The present-day river system developed on the Lake Longford 190-m sedimentary surface. In places these have exposed basalts resting on the 140-m surface below.

The modern Tamar Estuary occupies a valley within a valley, that is, a riverine erosion valley in sediments, contained within a structural rift valley basement of dolerite. A second volcanic dam within the valley has generated much of the modern landscape of the Northern Midlands.

ACKNOWLEDGEMENTS

This work is possible because of the detailed 1:25,000 geological maps, especially the 4 cm to 1 km (20 km east–west, 10 km north–south maps), generated by Mineral Resources Tasmania geologists (Department of Infrastructure Energy and Resources) for the Tamar region, mainly between 2004 and 2011 but embodying the work of many years. Years given are the years of completion of the 1:25,000 updates. Full details of the many contributors and sources are given on the respective published map sheets: BEACONSFIELD 2004, BELL BAY 2009, BLESSINGTON 2011, BRIDGENORTH 2004, DILSTON 2005, EXETER 2004, LAUNCESTON 2005, LILYDALE 2009, LONGFORD 2006, LOW HEAD 2009, NUNAMARA 2011, PORT SORELL NORTH 2004, PORT SORELL SOUTH 2004, PROSPECT 2005, RETREAT 2009.

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(accepted 7 May 2025)

APPENDIX
Table of events

Faulting. Rifting.	Volcanic Dam1 Batman area -60 to 140m	Volcanism Grindelwald	Volcanic Dam2 Cocked Hat Hill 140 to 190m	Volcanic Dam2 Stromboli 140 to 190m	Volcanic Dam2 Dolerite cgts. 140 to 190m	Sedimentation - mainly lacustrine some fluvial	Erosion Tamar
							180Ma
					dolerite intrusion		167Ma
Tension					erosion of Permo-Triassic cover rocks		
95Ma Faulting	seismicity				dolerite weathering starts		
80Ma Rifting	seismicity					basins separated by dolerite horst. L. TAMAR | L. LONGFORD	
Graben complete 65Ma	seismicity				dolerite weathering		
47Ma	Batman Rowella basalts						47Ma
	Volcanic Dam 1 start 47Ma					Lake levels equalise across 80m saddle in dolerite horst continue as LAKE TAMAR-LONGFORD	
	Volcanic Dam 1 complete at 140m retention level. Batman Rowella basalts continue				local deeply weathered dolerite		
140m top	VOLCANIC DAM 1	LAKE TAMAR-LONGFORD FILL COMPLETE			local re-worked conglomerate. seismicity	sedimention complete, surface of fill at 140m.	
	COLLAPSE, VD 1	seismicity	seismicity	seismicity	seismicity mass-movement dolerite conglomerate,	sedimentation downstream of collapsed volcanic dam 1	strong valley erosion
37Ma	Batman Rowella	volcanism start	volcanism start	volcanism start			
	lavas continue	basalts flow out on 140m surface.			locally re-worked		
		Grindelwald	Cocked Hat Hill	Stromboli			
			basalt - dolerite conglomerate synchronicity				
			VOLCANIC DAM 2				
33Ma	Batman Rowella	Grindelwald				LAKE LONGFORD only, start fill	valley head
	basalts	basalts					passes
			above Lake Tamar-Longford, 140 to 190m - LAKE LONGFORD FILL COMPLETE				airport
						Lake flows over horst. A 100m waterfall results, on Trevallyn fault scarp.	
25Ma	Georgetown basalts	25Ma				Waterfall retreating through columnar dolerite creates: CATARACT GORGE	near Evandale

LETTERS TO LONDON: LOUISA ANNE MEREDITH'S CONTRIBUTION TO SCIENTIFIC KNOWLEDGE THROUGH HER PAINTINGS OF TASMANIAN FISH

by Mary E Koolhof

(with three plates)

Koolhof, ME (2025). Letters to London: Louisa Anne Meredith's contribution to scientific knowledge through her paintings of Tasmanian fish. *Papers and Proceedings of the Royal Society of Tasmania*. 159: 39–46 ISSN: 0080-4703. Royal Society of Tasmania, PO Box 11, Franklin, Tasmania 7113, Australia. Email: office@rst.org.au

Louisa Anne Meredith's successful career as a writer, artist and naturalist has in many respects been well documented. She won numerous national and international awards for her botanical drawings and paintings, and her work as a natural history illustrator has received wide acclaim. Less known, however, is that Meredith's meticulous illustrations of Tasmanian indigenous fish played a key role in bringing Tasmanian fish to the notice of the scientific world, not only in Tasmania and Australia, but internationally. Letters throwing light on this achievement have been catalogued by the Natural History Museum, London, but appear not to have come to the previous attention of any historian or helped elevate her work as contributing to scientific knowledge.

Key Words: Louisa Anne Meredith, fish paintings, Royal Society of Tasmania, Dr A Günther, Professor F McCoy, Morton Allport, natural history illustration, British Museum, Natural History Museum.

Louisa Anne Meredith's successful career as a writer, artist and naturalist has in many respects been well documented. Her work as a natural history illustrator has been described as 'of wide popular appeal' and 'excellent source material' (Moyal 1993, pp. 176–177), and it is well known that she won numerous national and international awards for her wildflower paintings (O'Neill 1974, McCarthy 2018). Louisa Anne, also known as Mrs Charles Meredith (pl. 1A), was awarded Honorary Membership of the Royal Society of Tasmania in 1881 'in recognition of her long efforts to encourage the study of the Natural History of Tasmania, by illustrations both literary and pictorial, in her various and highly-popular publications' (Royal Society of Tasmania 1881, p. xii). Almost unknown today is Meredith's highly-skilled work in painting Tasmanian fish. Yet, when viewing her fish illustrations created more than 150 years ago, the paintings reveal remarkable vibrancy, scientific detail and accuracy appreciated by scientists and non-scientists alike (pl. 1B).

Correspondence throwing light on this skill comes from the naturalist Morton Allport in Hobart, together with four letters in Meredith's hand now held in the Natural History Museum, London, following transfer from the British Museum, and a letter by eminent Melbourne naturalist Frederick McCoy catalogued by the Natural History Museum. These letters reveal that Meredith's acclaimed illustrations of Tasmanian indigenous fish played a key role in bringing Tasmanian fish to the notice of the scientific world, not only in Tasmania and Australia, but internationally. It appears that none of these letters has previously attracted much attention, apart from a brief mention by Mollison (2020, p. 51) of Morton Allport sending a set of Meredith's fish illustrations to London.

PLATE 1A — Portrait of Louisa Anne Meredith by Georgiana McCrae, thought to have been painted in 1860 (in Clemente 2014, fig. 13).

In 1855, Meredith presented to the Royal Society of Tasmania (RST) a life-sized watercolour painting of a fish taken in a seine (fishing net) near South Cape. Her work was reported as a 'carefully executed coloured drawing

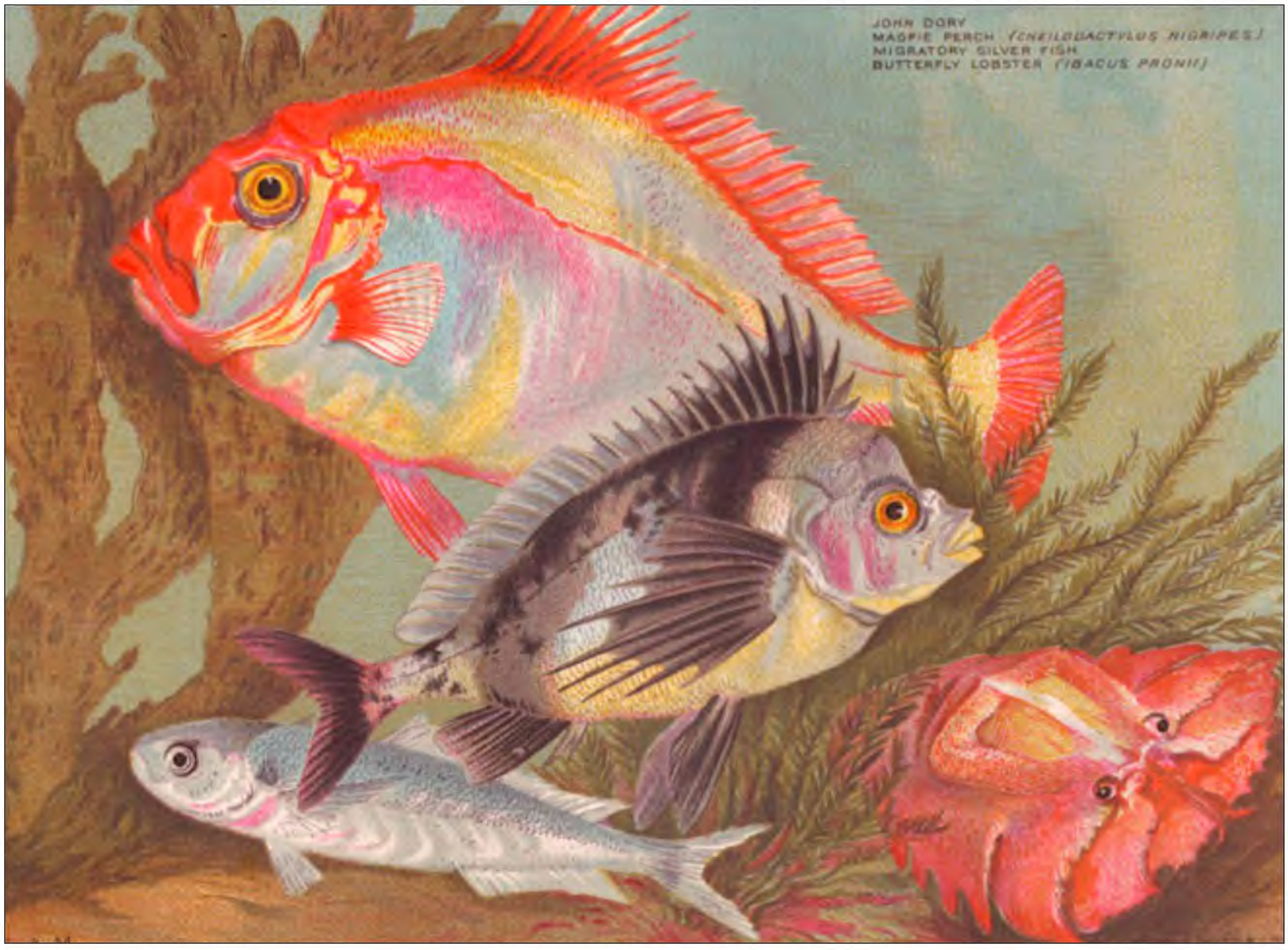

Plate 1B – Plate 5 from Meredith (1880) depicting a range of fish (and lobster) species with skill and accuracy.

… of a Fish (probably undescribed)' (*The Courier*, 27 December 1855, p. 2). So unusual was this fish and so peculiar its features that a newspaper article itemised every strange detail of the fish's appearance. Meredith's watercolour painting was described as '[a] very accurate and beautifully coloured drawing' (*The Courier*, 27 December 1855, p. 2). That fish is now known as the goblinfish *Glyptauchen panduratus*.

The RST minutes and meeting records, usually very restrained, are highly respectful of the skill evident in Meredith's fish watercolours and speak warmly of her work. In his paper 'Zoological statistics' read to the RST in 1862, TJ Ewing paid tribute to the work of Meredith:

> *… few of our fish have been drawn, as they come fresh from the sea with all their glowing but fleeting brilliancy. If we wish to see what some of these are, we have but to look at the beautiful drawings of Mrs Allport and Mrs Charles Meredith, presented to this society.* (Ewing 1863, p. 5)

A further example comes from 1864, when Meredith's son Owen found a strange-looking fish on a southern Tasmanian beach. Owen presented this fish to the RST, and at the next monthly meeting Louisa Anne Meredith presented to the same society 'an excellent and very accurate water colour drawing … of the fish presented by Mr Owen Meredith at the last meeting' (Royal Society of Tasmania 1864b, p. 103). Tasmanian naturalist Morton Allport remarked: 'Owing to the absence of any standard modern work on fish, it was impossible to give the scientific name of the curious specimen presented by Mr Meredith, but it is probably allied to the anglers, or frog-fish (*Lophius*, sp. ?)' (Royal Society of Tasmania 1864a, p. 90). The fish depicted is today known as *Brachionichthys hirsutus,* the critically endangered spotted handfish. Meredith's painting of this fish merited mention by RM Johnston in his 'Classified Catalogue of all the known Tasmanian Fish Species' in the Fisheries Royal Commission Report of 1883: 'Mrs Meredith has very faithfully painted this species in her Tasmanian Friends and Foes, under the name tortoiseshell fish *Cheironectes politus*' (The Commissioners 1883, p. liii) (pl. 2A). Such was his regard, Johnston also mentioned Meredith's book in his bibliography of the catalogue, referencing its figures and notes (Johnston 1883, p. xlv). This was high praise from the meticulous Johnston, scientist, statistician, Fellow of the Linnean Society of London, Fellow of the Royal Geographical Society of Australasia and later Vice-President of the Royal Society of Tasmania, indicating the esteem in which he held Meredith's work. As it transpired, the difference in the name given by Meredith, *Cheironectes politus,* and that of *Brachionichthys hirsutus* as reported by Johnston, was due to handfish nomenclature being under review at the time (Last & Gledhill 2009, p. 5).

The quality of Meredith's work is apparent in a comparison of one of her painstakingly-detailed handfish

paintings with those of well-known artists William Buelow Gould and Thomas Bock made during similar periods (pl. 2B, 2C; also see Last & Gledhill 2009, p. 6).

Letters from Hobart naturalist Morton Allport (Allport 1872, 1873, 1874) describe his sending a set of Meredith's paintings of Tasmanian fish to the distinguished Dr ACLG Günther, Keeper of Zoology at the British Museum, London, and arranging for their return. For years Allport had been sending preserved fish to Dr Günther for scientific purposes. Some of the specimens proved to be new to science; others were known species that had not previously been recorded in Tasmanian waters (The Commissioners 1883, p. xxix).

Allport noted that the colours of the specimens he sent were 'quite destroyed' by the preservation method used. He sent Meredith's paintings in order that a pre-eminent scientist could appreciate the precise markings and beautiful colours of the Tasmanian fish, writing: 'Many of the more brilliantly coloured species [such] as Phyllopteryx are quite destroyed in Spirit and the preparations give no notion of their beauty' (Allport 1872) (pl. 3).

In his letter to Dr Günther of 10 August 1872, Allport wrote:

> *By Post in a separate parcel I send six sketches by a lady whom I have known for many years (Mrs Meredith) and who would be willing to continue sending other illustrations of our indigenous fish if they could be made serviceable and the originals be returned to her – Mrs Meredith's own remarks on these specimens accompany the sketches. … The Cestracion, Histiopterus and Cheilodactylus you will have no difficulty in recognising – the latter is C. Nigripes. What Mrs M. calls the Silver Trevally I believe to be Caranx georgianus the one spoken of as "English Trevally" I do not know.*
>
> *Can these sketches be made available either through the Zoological Society or otherwise for the purpose of showing the colours of recent specimens.* (Allport 1872)

Allport clearly considered that Meredith's paintings of the fishes she called 'Silver Trevally' and 'English Trevally' would be useful to Günther in making a scientific identification. Morton Allport was Vice-President of the RST and an authority on Tasmanian zoology, corresponding prolifically with scientific experts in Europe (Stilwell 1969). The tone of Allport's letter to Günther is very telling; he has great respect for Meredith and feels keenly the responsibility to return her paintings safely. He wrote to Günther: 'You will see by Mrs Meredith's notes that she looks to me for the careful transmission of the pictures and I shall be obliged by your returning them in the same way as they are sent' (Allport 1872).

Equally telling is his statement in the same letter: 'Mrs Meredith's own remarks on these specimens accompany the sketches' (Allport 1872), implying that Meredith had supplied observations worthy of the attention of the much-published Keeper of Zoology at the British Museum. Dr Günther was a most eminent ichthyologist, a Fellow of the Zoological Society and the Linnean Society of London; a Fellow, Gold Medallist and later, President of the Royal

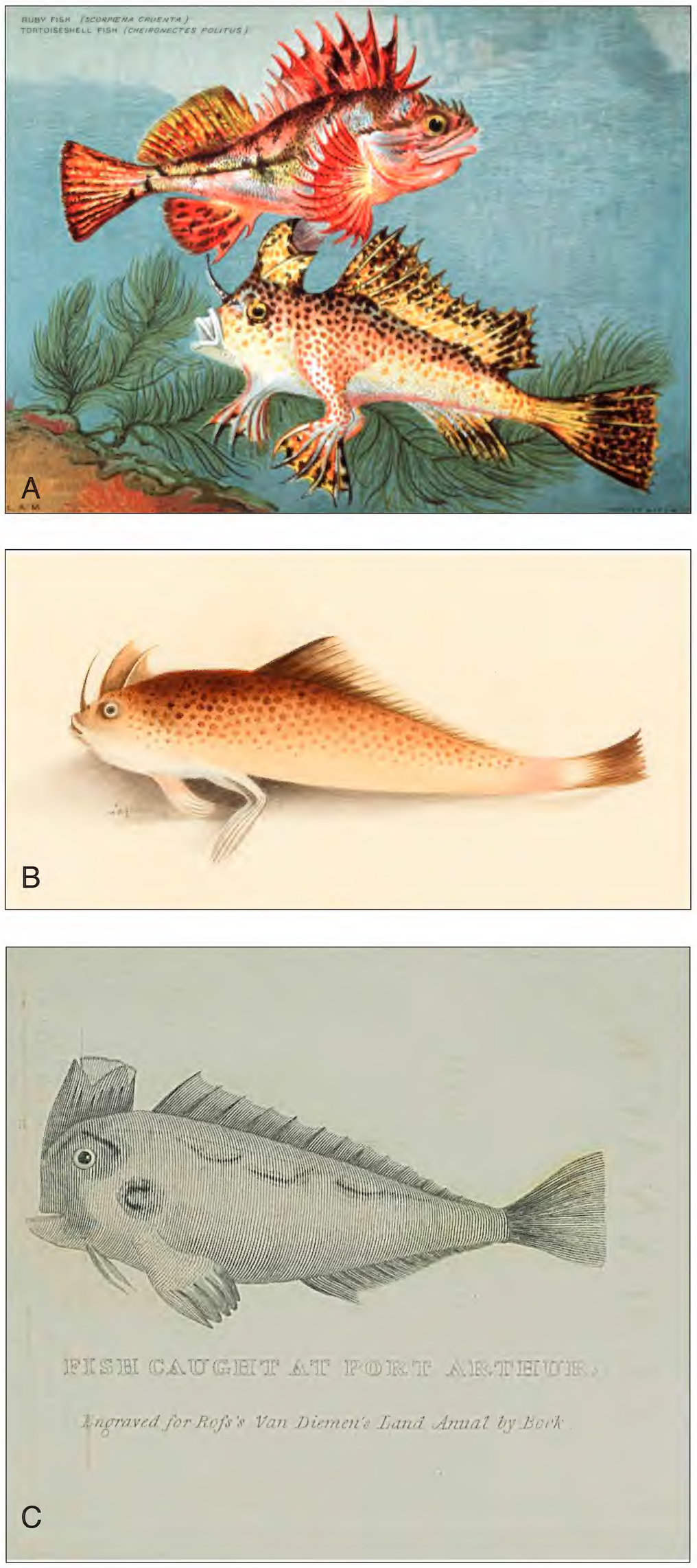

PLATE 2 — Comparison of detail between three early illustrations of handfish. **A** Spotted handfish by Meredith, figured as a 'Tortoiseshell Fish' (Meredith 1880, Plate 8, bottom specimen), **B** Spotted handfish illustrated by WB Gould (ca. 1832), figured as a 'Walking Fish' (Gould 1832), **C** Copper engraving of red handfish by T Bock, figured as 'Fish caught at Port Arthur' (Ross 1835, inside cover). (Species identified in Last & Gledhill 2009, p. 6.)

PLATE 3 — Plate 7 from Meredith (1880) showing the vivid colours of the superb dragon and Shaw's cowfish, often lost when stored in spirits.

Society of London, who had published a highly-regarded eight-volume *Catalogue of the Fishes in the British Museum* (Smith 2005). It was the British Museum which set the standard for natural history discourse in the nineteenth century (McOuat 2001, p. 1).

It is evident that Meredith, a woman of no academic standing who had been home-educated by her mother and a governess (Ellis 1979, p. 29), commanded the respect and esteem of these leading scientists of the day. It may also seem astonishing that an artist with limited formal training living in colonial rural Tasmania could have her work proposed as being of use to the Zoological Society of London, in addition to the British Museum. Meredith (née Twamley) had been a precocious child and began her career as a writer and artist in her teens when living in Birmingham, England, where she moved in artistic circles and received advice on painting from Sir Thomas Lawrence, President of the Royal Academy (Ellis 1979, pp. 20–33). In exploring Meredith's sense of identity in adult life, Miller (2014, p. 71) observed:

> *Meredith's education and the income she received from her writing meant that she was not a woman dependent entirely on her husband. Furthermore, Meredith asserted intellectual independence and her own intellectual identity, and had done this before her marriage.*

Amelia Scurry noted relatively recently that the character and style of Meredith's paintings of fish, marine worms and shells suggest that she was 'working within the tradition of natural history illustration and deliberately producing species studies'. Further, Scurry comments that in Meredith's six major Tasmanian publications destined for English and American audiences, she revealed 'a developing interest and focus on a scientific method of observation and the documentation of ecological diversity' (Scurry in Horne 2009, p. 179).

Many sources write that Meredith travelled to London in 1891; however, the shipping records reveal that she embarked on the sea voyage to London in 1890, accompanied by Miss Meredith, her granddaughter, departing Australia on the *Salazie* bound for Marseilles via Melbourne (*Sydney Mail and New South Wales Advertiser*, 1890, p. 495). From Meredith's letter of 6 May 1890, we know she was living in London on that date, at 38 Cambridge Terrace, Hyde Park. Meredith had equipped herself for her London stay with a letter of introduction to Dr Günther from the much-decorated Sir Fredrick McCoy FRS, professor and museum director, possibly

collecting the letter from McCoy when the *Salazie* docked in Melbourne on 27 February *en route* to Marseilles (*The Argus*, 28 February 1890, p. 4).

McCoy had been awarded a DSc (Cantab.), 1886; CMG, 1886; KCMG, 1891; and royal honours from Italy and Austria. He had served as a commissioner for the Victorian (1861), Intercolonial (1866) and International (1880) Exhibitions and was an honorary member of learned societies in Cambridge, Edinburgh, London, Manchester, Moscow, New Zealand and Sydney (Fendley 1974). McCoy's identifications and classifications of fish had been cited in Johnston's *General and Critical Observations of the Fishes of Tasmania* and the *Classified Catalogue of the Fishes of Tasmania* (Johnston 1883). It is evident that not only was McCoy a leading ichthyologist of the day, he also had a close knowledge of Tasmanian fish.

McCoy's letter reveals his deepest admiration for the skilful work of Meredith in depicting Tasmanian fish, writing:

> *My dear Dr Günther*
> *Pray allow me to give you the greatest pleasure you have ever had in your life by making you personally known to Mrs Meredith, whose admirable works and beautiful figures of Tasmanian Fishes you have often quoted.* (McCoy 1890)

Nothing could indicate more clearly a scion of the Melbourne establishment than this letter headed 'University Melbourne', on writing paper bearing the seal of the Melbourne Club. McCoy's statement that by effecting an introduction to Meredith, he would be conferring on Günther 'the greatest pleasure he has ever had in his life', is extravagant praise indeed. His acquaintance with Meredith was of long standing; in 1856 McCoy had shown her around the grounds of the University of Melbourne (Clemente 2014).

From McCoy's letter of introduction, we also learn that Günther often quoted Meredith's 'admirable works and beautiful figures of Tasmanian fishes' (McCoy 1890), presumably in conversation and correspondence with other learned people. This reveals a singular respect for Meredith's fish illustrations by an eminent scientist of the day. Far from Morton Allport's correspondence from Hobart with Günther in London regarding Meredith's fish illustrations being an isolated example, Allport's high regard for the quality and accurate depictions in Meredith's fish paintings reinforces the point.

An unsolved mystery is contained in McCoy's letter. He wrote: 'This is about publishing another work on Tasmanian Natural History and will show you the most beautiful drawings from the life, you ever saw of Tasmanian Fish' (McCoy 1890). The new 'written work on Tasmanian Natural History' referred to by McCoy is an enigma. At the time, Meredith was taking to London material for the publication of her book *Bush Friends in Tasmania: Last Series,* which did not include fish. Was Meredith planning another volume, one featuring her watercolour illustrations of Tasmanian fish, correctly identified with their scientific names by Dr Günther? This could certainly be inferred from McCoy's letter and Meredith's subsequent letters to Günther.

On 6 May 1890, Meredith wrote the first of a series of four letters to Günther in London, enclosing '[a] hyperbolical note from my kind but too flattering friend…'; that 'note' is almost certainly the letter of introduction from McCoy:

> *My dear Sir,*
> *I hesitate and really blush, to send you this hyperbolical note from my kind but too flattering friend, which I enclose and should fear to lay my sketches before you, but that I believe you approved some, sent to you some years ago, by the late Morton Allport – I am writing to ask Professor Flower if I may show him, and thought it might be convenient for you to see them at the same time – I will send this note to his care, to assist arrangements.* (Meredith 1890)

The 'Professor Flower' referred to in this letter was Sir WH Flower, Director of the Natural History Department at the British Museum and President of the Zoological Society of London (The British Museum). In Meredith's next letter to Günther of 28 September 1891, she wrote:

> *Dear Sir,*
> *Last year, when I had the pleasure of showing you my drawings of Tasmanian fish, you were so kind as to say you would write on them the correct scientific names, (altho [sic] they were not so minutely accurate as they should be, as to fins) and I shall be very much obliged to you if you will do so – and will send them to the Museum by "parcel delivery", if I hear from you that I may – I leave England to return to Tasmania early next month.* (Meredith 1891a)

Her self-deprecating manner is again evident in the comment 'my drawings of Tasmanian fish … were not so minutely accurate as they should be, as to fins'. The quality of the drawings, and Günther's regard for Meredith, were evidently sufficiently high to induce a busy and eminent professional man to find the time to inspect and personally provide the scientific names of the fish illustrated, in a short period of time.

Meredith's self-effacing remark echoes her previous 'Memoranda' of 8 July 1878 in which she donated seven minutely-detailed paintings of marine worms to the RST, accompanied by 12 pages of punctilious notes:

> *I fear so unscientific a description is of little value, except to convey a faint idea of the living aspects of the beautiful and interesting creatures whose portraits, faithful as my pencil might achieve, I have the pleasure of presenting to Dr Agnew, for the Royal Society.* (Meredith 1878, pp. 11–12)

Her letter of 8 October expresses her thanks to Günther for promising to name her drawings and makes arrangements for sending them to the British Museum: 'I thank you very much for your kind promise to name my fish drawings, and will send them to you at the Museum, after the 16th' (Meredith 1891b).

In Meredith's fourth letter to Dr Günther of 20 October, she adopted a warm and respectful tone, gracefully acknowledging Günther's professional advice:

> *I have sent the fish in a portfolio, and desired the carrier to ask when he might call for it again – will you kindly write the names on the drawings, or if on*

> *the mounts close to the drawings – I shall value these very much and if I ever attempt any more fish-portraits shall remember what you told me as to more exact and minute accuracy in the fins and scales … With many thanks for your kindness in naming my sketches…* (Meredith 1891c)

Previous correspondence reveals that, in reality, Meredith was not always a modest person. In a letter written in 1878 she had declared to her old friend Sir Henry Parkes: 'I believe that no other woman resident in the Colony has done so much in art, science and literature for her adopted country, and I think forty years of active work deserve their reward' (in Clemente 2014), yet in her letters to Günther she appears to consciously adopt a self-deprecating tone that stops short of being ingratiating. Meredith's underlying confidence in her artistic work can be detected in her letters, along with a thin thread of steel in her written voice when she asked Dr Günther: 'Will Saturday be too soon for the portfolio to be called for? We leave London early in [sic] next week' (Meredith 1891c).

The deferential remarks abounding in Meredith's writing have previously been noted by Dunscombe (1998, p. 17): 'Meredith's literary writing is loaded with an awareness and foregrounding of her less authoritative status as a woman author, and she quite consciously cultivates the authorial persona of accomplished amateur throughout her literary career'. Meredith's letters to Günther reveal that she adopted the same approach when writing about her fish illustrations, and Dunscombe's observations on Meredith's literary work apply equally to her watercolour paintings of Tasmanian fish: 'As a woman, she clearly took her exclusion from the domain of the expert as a "given"' (Dunscombe 1998, p. 18).

Kerr (1984) refers to 'the context of the "Lady Painter", that notoriously underrated race'. Women painters in colonial Australia are separated by Kerr into two main categories: the 'pioneers', who sketched and painted their new lives as a record to keep or send to relatives overseas; and the 'accomplished gentlewomen' of the drawing room who painted birds, flowers and views, their art being more decorative than informative (Kerr 1984, p. 3). While describing Meredith as of unusual competence, Kerr places Meredith in the 'pioneer' and 'accomplished gentlewoman' categories, citing her exceptionally competent flower paintings (pp. 9–11). She does not credit the importance of Meredith's fish paintings as accomplished natural history illustrations, other than briefly mentioning that Meredith painted the 'frog fish' [spotted handfish] (Kerr 1984, p. 14).

In discussing nineteenth-century female colonial artists including Louisa Anne Meredith, Jordan (2005, p. 176) referred to their 'affectionate anthropomorphised representations of native fauna'. In the case of Meredith's paintings, the fish, although vivid, are neither affectionately rendered nor anthropomorphised but accurately depicted and dispassionate.

Carey (2023) noted that the contribution by women to Australian science is significantly more extensive, complex and nuanced than may be generally thought, and that their contributions remain largely hidden. With regard to the role of women in nature writing, Carey remarks that Meredith was typical in the way she adopted the persona of an amateur in her 'intrusion' into the scientific realm. In analysing passages in Meredith's *Notes and Sketches of New South Wales*, Carey observeed that Meredith's writing was infused with scientific references that contradicted this stance (Carey 2023, p. 23). Meredith's previously-mentioned 'Memoranda' on the paintings of tiny marine worms she donated to the RST in 1878 provide a further example of this: in her postscript to the 'Memoranda', Meredith offers her thanks to Mr RM Johnston for assigning the worms to their probable genera, adding that 'he thinks they are most likely species hitherto unnoticed' (Meredith 1878).

Meredith's approach to learned gentlemen, combining modesty and flattery, appears to have been a conscious strategy to promote acceptance and recognition of her natural history work. In her private life, quite a different picture is presented of her social manner. Tasmanian lithographer, printer and picture framer RL Hood, who took over his father's business in Hobart in 1851 (McArthur 1988, p. 60), narrated a first-hand encounter with Meredith:

> *I was hanging some pictures for Mrs Cameron, living at Heathfield, Davey St one day, and among them was a Glover – same with Gum Trees. Mrs Charles Meredith came into the room and said "I am told you have a Glover there Mr Hood, may I see it?" I turned the picture around, & she looked at it for a second, and turned impetuously towards the door, saying as she went out "Just like all of Glovers, he never could paint a Gum Tree. He puts all his trees to the front, – leaves behind!" Mrs Cameron came in afterwards and asked me what Mrs M. said about the picture, and when I told her she seemed very much annoyed and said 'She might have kept that to herself'. Charles Meredith was just after the same style – imperious, push-you-aside style.* (Hood nd)

Her brusqueness in this encounter is quite at odds with the tone she adopted in written communications with scientists, as exemplified by her notes on marine worms to Dr Agnew, (Meredith 1878) and letters to Dr Günther (Meredith 1890, 1891a, b, c). On viewing ten of Meredith's fish illustrations at a Melbourne exhibition in 2009, evolutionary biologist Mark Elgar from the University of Melbourne noted his surprise at seeing the 'vivid images of Tasmanian fish'. Elgar observed that Meredith had corresponded with many scientists and was an authority on Tasmanian natural history (Elgar 2009, p. 732).

Gates (2005, p. 78) posited that one of the reasons colonial women naturalists and illustrators such as Meredith have been inadequately recognised in either the history of colonisation or the history of science is that the audience for their work has been underestimated, and that there was actually a large number of people '… hungry for new information about the world's flora and fauna and ready to read or view information from anyone who could describe this exotic world outside Britain'. Also observed by Gates (2006, pp. 192–196) is the way the combination of text and images in Meredith's books aided the spread of scientific

knowledge, commenting that *Tasmanian Friends and Foes: Feathered, Furred and Finned* (Meredith 1880) 'covers a multiplicity of possible audiences for her popular science writing by means of her fictional characters, her labels, and her footnotes'. It is worth noting that the pension awarded to Meredith by the Tasmanian government towards the end of her life was for her work in having 'by her writings and paintings rendered considerable services to the cause of Science, Literature, and Art in Tasmania' (Moyal 1986, in Gates 2005, p. 86).

This begs the question: for this woman who was 'an authority on Tasmanian natural history', where is the recognition from the learned men, both professional and amateur scientists, who admired and used her work? Where are the citations and the accolades? Brief mentions in private letters; occasional comments in the RST records; citations of her illustrations such as by Johnston (1883, p. liii), Ewing (1863, p. 5) and Scott (1933, p. 35): that appears to be the extent of it. It is evident from the letters cited in this article that, in the English-speaking world, there was in the nineteenth century a circle of male professional and amateur ichthyologists corresponding, sending specimens and citing each other's published work, with Dr Günther at the centre. An overview of women in science in Australia from 1830–1950 concluded, in part:

> *From their earliest participation, women contributors to scientific knowledge and information in Australia have been marginalised and rendered largely invisible in the record of science. … Across the nineteenth century, scientific 'amateurs and gentlemen' accepted women in the cultural background, used their services and data, and, even before professionalization grew, edged them from the mainstream of science.* (Moyal 1993, pp. 184–185)

Such seems to have been the case for Meredith.

In no way does this diminish Louisa Anne Meredith's consummate skill as an observer, collector and illustrator of natural history specimens. The value of her paintings in bringing to life the beautiful colours of Tasmanian fish for scientists on the other side of the world as well as closer to home, and assisting with the identification and documentation of specimens, adds an important scientific dimension to Meredith's magnificent *oeuvre*.

In recognition of her contributions Meredith was awarded Honorary Membership of the Royal Society of Tasmania in 1881, the first woman to receive this honour. Meredith, as a female, was not precluded from ordinary membership of the RST. From inception, the Society (originally the Botanical & Horticultural Society of Van Diemen's Land, before receiving royal patronage in 1844), specified that 'Ladies may be admitted as Fellows upon the same terms, with the same privileges, and under the same Regulations in all respects as Gentlemen' (Botanical & Horticultural Society of Van Diemen's Land 1843, Rule VIII, pp. 7–8). In 2023, the RST established the Louisa Anne Meredith Medal to be awarded to similarly worthy recipients. The medal was first awarded in 2024.

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DISTRIBUTION, HABITAT AND CONSERVATION STATUS OF *ENGAEUS GRANULATUS* (DECAPODA: PARASTACIDAE) AND RELATED SPECIES OF FRESHWATER BURROWING CRAYFISH IN CENTRAL NORTHERN TASMANIA

by Alastair MM Richardson, Mark Wapstra and Ryan Francis

(with four figures and two tables)

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The distribution and habitat of *Engaeus granulatus* are reviewed. The species is restricted to a relatively small area in central northern Lutruwita/Tasmania between Devonport in the west, Asbestos Range in the east and Sheffield to the south. The habitat of *E. granulatus* includes swamps, floodplains of small creeks, poorly-drained areas in paddocks and roadside/railway ditches. The range of *E. granulatus* overlaps to varying degrees with *E. mairener, E. nulloporius, E. fossor, E. cisternarius*, *E. cunicularius* and *E. excavator*. It is not possible to identify the species by reference to characteristics of the burrow or habitat (although it can be a useful guide). Burrow excavation remains the only means of identifying the occupant pending development of non-invasive means, such as eDNA. With the recent description of *E. excavator* from within the core range of *E. granulatus*, and the overlap with five other species, the conservation status of *E. granulatus* is probably even more tenuous than previously thought: while its extent of occurrence remains similar, its area of occupancy within this extent may be significantly less than previously suggested.

Key Words: burrowing crayfish, *Engaeus*, Tasmania, Australia, conservation status.

INTRODUCTION

Burrowing crayfish in the genus *Engaeus* are found in southeastern Australia, including northern and western Lutruwita/Tasmania. The genus was last revised by Horwitz (1990) and since then two further species have been described (Horwitz 1994, Richardson 2024). Most species of *Engaeus* are primary burrowers (*sensu* Hobbs 1981) and several species construct type 3 burrows (Horwitz & Richardson 1986), i.e., burrows that store water above the water table, making them among the world's most terrestrialised crayfish. The burrowing lifestyle constrains dispersal of juveniles, especially if the burrows are not in direct contact with surface water, with the result that several *Engaeus* species are short-range endemics. Small, geographically restricted populations of these essentially sedentary animals render them vulnerable to habitat changes and stochastic events, so some of them are of conservation concern. In Tasmania, five species are currently listed under Tasmania's *Threatened Species Protection Act 1995* (TSPA) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA), three as nationally endangered (table 1).

The central north burrowing crayfish, *Engaeus granulatus* Horwitz 1990, has a restricted distribution between Devonport in the west, Asbestos Range in the east and Sheffield to the south (fig. 1). Its range includes intensive farming on productive agricultural soils, the Devonport conurbation, the Railton limestone quarry, cement works and associated rail line, and other developments, all of which have severely fragmented its populations leading to its endangered status (Doran 2000). Burrows of this species are vulnerable to activities that involve excavation or lowering of the water table, for example in maintaining roadside and rail-side drains, installing irrigation systems or developing subdivisions. Even if the crayfish survives its burrow being excavated it does not have the ability to dig a new burrow fast enough to survive, and if the water table is lowered below the bottom of the burrow the crayfish will die from desiccation.

Horwitz *et al.* (1990) suggested that *E. granulatus* forms a clade with two other species: *E. mairener* Horwitz 1990 and *E. nulloporius* Horwitz 1990, and a preliminary genetic analysis suggests that the recently identified *E. excavator* Richardson 2024 can be added to this clade (Richardson unpubl. data). The species within the clade are morphologically similar, varying only in sternal pore arrangements, setation and granulation on the claws. Further, the chela, abdomen and carapace sizes and ratios are similar. The morphological similarities are mirrored by their habitat preferences, with all four species predominantly constructing type 2 burrows, often in clay subsoils in areas containing shallow groundwater, or around springs and seeps.

Burrowing crayfish present special problems for the environmental surveys required for proposed developments:

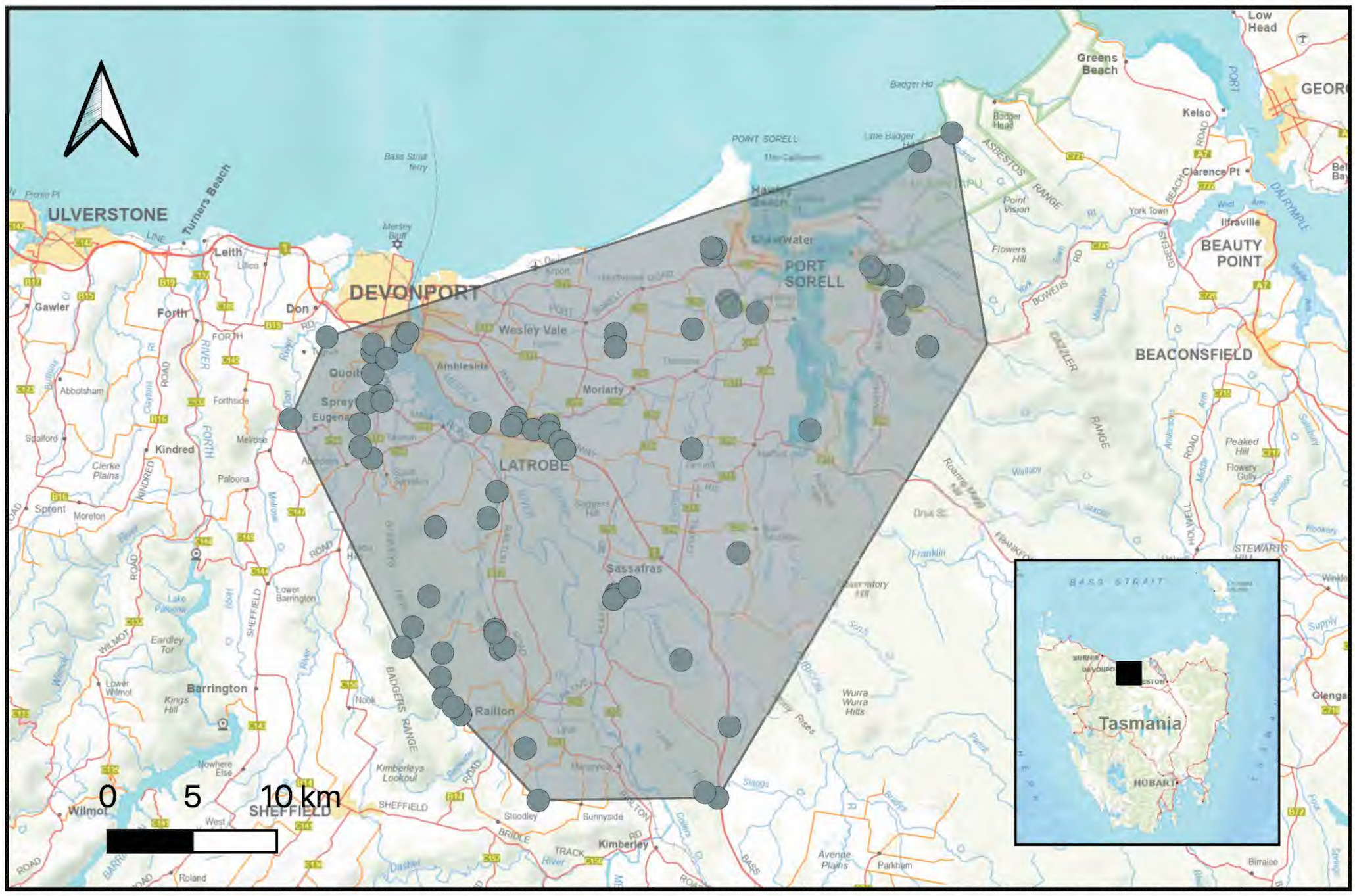

FIG. 1 — Minimum convex polygon representing the geographical range of *Engaeus granulatus* (grey dots) from reliable NVA records (Base map: ListMap).

TABLE 1 — *Engaeus* species in Lutruwita/Tasmania and their conservation listing under the Tasmanian *Threatened Species Protection Act 1995* (TSPA) and Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBCA).

Species	TSPA	EPBCA
Engaeus cunicularius		
E. cisternarius		
E. disjuncticus		
E. excavator		
E. fossor		
E. granulatus	EN[1]	EN
E. laevis		
E. lengana		
E. leptorhynchus		
E. mairener		
E. martigener	VU[2]	EN
E. nulloporius		
E. orramakunna	VU	VU
E. spinicaudatus	EN	EN
E. tayatea		
E. yabbimunna	VU	VU

[1] Endangered; [2] Vulnerable

their burrows are not always easy to find, and when found it may require hours of labour to extract and identify the crayfish species. Furthermore, excavation destroys the burrow and can damage surrounding habitat, so excavation should be avoided where possible. Richardson *et al.* (2008) suggested that *E. granulatus* occupies an exclusive central range, leading to the assumption that crayfish burrows found within that core range, at sites of interest in land management issues for example, could be assigned to *E. granulatus,* thus avoiding the need for excavations. However, as records have accumulated, that assumption has been increasingly challenged.

This paper summarises the current state of knowledge on *E. granulatus* and associated crayfish species and makes recommendations for assessing burrowing crayfish occurrences in the central north region. We seek to answer two questions: is there an exclusive core range within which any burrow can be assumed to be that of *E. granulatus,* and can we identify the total range of *E. granulatus* with enough accuracy to set a boundary beyond which burrows do not need to be checked for *E. granulatus* in the event of proposed development activities?

METHODS

The Tasmanian *Natural Values Atlas* (www.naturalvaluesatlas.tas.gov.au) (NVA), contains the most current records of freshwater crayfish in the state. As well as casual records going back many decades, all records from recent environmental surveys must be lodged in this database as a permit condition, hence it provides the best available data to assess current species' ranges. However, burrowing crayfish present a special issue with this system in that it is not always clear whether records are of a specimen reliably identified in the hand, or simply the presence of a burrow that has been assumed to be of a particular species. This has been particularly the case for *E. granulatus*, because of an expectation that it has an exclusive core range.

Records of *E. granulatus* and the following species were extracted from the NVA on 26 May 2025: *E. mairener, E. nulloporius, E. fossor, E. cisternarius* and *E. cunicularius*. The ranges of these burrowing species all appear to be contiguous with, or overlap, that of *E. granulatus*. A further species, *E. disjuncticus* Horwitz 1990, can be found within 12 km of the *E. granulatus* range, and an envelope including all its known records would overlap with *E. granulatus*. *E. disjuncticus*, as the name suggests, has an anomalous, disjunct range, but it is currently unclear whether the separate occurrences are natural or the result of under-collecting, so it has been excluded from this analysis.

E. granulatus records were filtered to minimise the chance of misidentification, or records based simply on burrows. Only records from collectors with known expertise in identification were accepted, and within these all records with 'assumed' in the Notes field were rejected.

Crayfish records were mapped and analysed using QGIS Ver 3.38. Minimum convex polygons were constructed around the filtered records of each species using the Minimum Bounding Geometry routine in QGIS. Areas of polygons and overlaps were determined using the QGIS Field Calculator.

RESULTS

The NVA yielded 273 records of *Engaeus granulatus*, but after filtering, these were reduced to 86. The range as defined by the most reliable records only deviates a little from the all-records range. In the southeast, records from Browns Creek, and south of Drys Sugarloaf, are well outside the reliable records range, but in both cases the collectors recorded the identification as 'assumed'. To the north, two other unverified records would extend the range slightly westwards across Devonport and close to the coast. Within a 5 km buffer around the reliable records range, there are at least seven records of three other *Engaeus* species, giving some indication of crayfish surveys that have not located *E. granulatus*.

The distributions of six other *Engaeus* species overlap with that of *E. granulatus*: *E. fossor, E. cisternarius, E. mairener, E. cunicularius, E. nulloporius* and *E. excavator*. Minimum convex polygons are a crude but objective way of representing the range of a species from a set of point records. Convex polygons were created for all species and overlaid on that of *E. granulatus* (fig. 2A–F). The current known range of *E. excavator* is very small and lies completely within the range of *E. granulatus* on the eastern outskirts of Latrobe (fig. 2A). The degree to which these species overlap with the range of *E. granulatus*, their habitat and the likelihood that their burrows might be confused with those of *E. granulatus,* have been summarised (table 2).

E. fossor and *E. cisternarius* both have very large ranges in the west of Tasmania. *E. fossor* penetrates the west and south of the *E. granulatus* range (fig. 2B) and its habitat requirements are similar to those of *E. granulatus* (Suter & Richardson 1977, Horwitz 1990). *E. cisternarius* also overlaps from the west (fig. 2C), but its burrows are usually type 3 (i.e., perched above the water table, Horwitz & Richardson 1986) so are unlikely to be fully sympatric with, or confused with, those of *E. granulatus*. However, where *E. cisternarius* and *E. granulatus* are sympatric, the locations of burrows need to be carefully scrutinised, as the microhabitat change can occur over less than 1 m. *E. cisternarius* burrow systems have entrances in the walls of gullies, often on steep slopes, above surface waters and seeps, often without visible chimneys. *E. granulatus* and *E. fossor* burrows have visible chimneys in areas with surface water or areas that are saturated and muddy.

E. mairener has an extensive range in northeastern Tasmania. It has the largest overlap with *E. granulatus*, extending from its eastern boundary to the Mersey River (fig. 2D). *E. mairener* constructs type 2 burrows in a range of habitats from stream floodplains to open paddocks (Horwitz 1990, Richardson pers. obs.).

E. cunicularius appears to have a near-coastal range, at least in the central north. The few records within the range of *E. granulatus* (fig. 2E) are all within 1–2 km of the coast. It constructs burrows close to creeks: type 1b burrows with entrances above and below the water, and older, more complex type 2 burrows a little further away (Horwitz 1990).

The recently described *E. excavator* has currently the smallest known range overlap with *E. granulatus* (fig. 2A). *E. excavator* is known from just two sites a few kilometres apart on the outskirts of Latrobe (Richardson 2024). At both sites the species was found in established paddocks, in deep type 2 burrows in predominantly clay soils.

Finally, *E. nulloporius* has a small overlap in the southeast of the range of *E. granulatus* (fig. 2F). It constructs type 1b and type 2 burrows, usually in clay soils close to creeks and swamps. Horwitz (1990) recorded it in sympatry with *E. granulatus* near Elizabeth Town, though this record is not in the NVA.

DISCUSSION

When the ranges of these six species of *Engaeus* are superimposed on the range of *E. granulatus* (fig. 3), there is little evidence that *E. granulatus* has an exclusive range. Only a narrow strip of land, about 19 km long and 4–9 km

TABLE 2 — Species of *Engaeus* with ranges overlapping, or very close to, that of *Engaeus granulatus,* showing the percentage overlap of their minimum convex polygons ranges; burrow type, (following Horwitz & Richardson 1986) and likelihood of confusion with *E. granulatus*

Species	% range overlap	Burrow type[1]	Burrows may be confused with *E. granulatus*?	Reference
Engaeus fossor	28.8	2	Yes	Suter & Richardson (1977), Horwitz (1990)
E. mairener	42.3	1b, 2	Yes	Horwitz (1990)
E. cisternarius	2.5	3	Unlikely due to habitat, but differences are subtle	Suter & Richardson (1977), Horwitz (1990)
E. cunicularius	16.6	1b, 2	Only within 2–3 km of coast, but beware estuaries	Horwitz ((1990)
E. excavator	<0.1	2	Yes	Richardson 2024)
E. nulloporius	1.6	2	Yes	Horwitz (1990)

[1] Burrow type 1b associated with standing water, burrow entrances above and below the surface; burrow type 2 not directly associated with surface water, but always descending to the water table; burrow type 3 not associated with standing water but perched above the water table

wide, from Tugrah to south of Sassafras, is not overlapped by any of the other species based on present records (fig. 3). Part of this strip is close to the Mersey estuary, which could potentially be habitat of *E. cunicularius*, and much of the northern part is within the area identified by Richardson (2024) as potential habitat for *E. excavator*. Even though there appears to be a small part of the range of *E. granulatus* exclusive of all other species, it would be risky to assume that every burrow there belongs to that species.

Is it possible to distinguish *E. granulatus* burrows by their external form or by the microhabitat? Only in a very few cases can crayfish be identified by their burrow openings, and even then, identification is unreliable (Richardson & Swain 1991). Only experienced observers can suggest a species' identity from burrow form and microhabitat. *E. granulatus* has been found in a range of habitats from swamps, floodplains of small creeks (Horwitz 1990, Richardson *et al.* 2008), poorly drained areas in paddocks, and in ditches and drains associated with road and rail infrastructure. *E. fossor* and *E. mairener* are both commonly found in swamps and floodplains, while *E. mairener, E. nulloporius* and *E. excavator* can also be found in damp patches in paddocks usually colonised by species of rush (*Juncus* spp.) and sedge (e.g., *Carex* spp., *Gahnia* spp., *Lepidosperma* spp.). The differences between the habitat preferences of Tasmanian burrowing crayfish can be subtle, usually in terms of soil drainage, water table depth and soil type (Suter & Richardson 1977, Richardson & Horwitz 1988, Richardson & Swain 1991, Hopgood-Douglas 2005), but with the current state of knowledge it is not possible to distinguish *E. granulatus* burrows from those of these other species in the field.

How precisely can the range of *E. granulatus* now be defined? It is impossible to state confidently where a species does not occur, but where other species of crayfish have been identified outside the *E. granulatus* range but in suitable habitat, then its absence can be inferred. Figure 4 shows the occurrences of other *Engaeus* species near the range of *E. granulatus*, with nominal 2 km and 5 km buffers. While there are some records of other species to the south and west of the range, there are large zones to the east and southeast without crayfish records, where the edge of the range remains uncertain.

It is unlikely that the minimum convex polygon precisely marks the edge of the range of *E. granulatus*: burrows within a buffer of at least 2 km should be checked along its western boundary, and to 5 km or more along the southern and eastern boundary. Environmental domain modelling by Richardson *et al.* (2008) suggested that suitable conditions for *E. granulatus*, in terms of climate and topography, exist to the east of the Asbestos and Dazzler ranges, but its presence there has not yet been confirmed.

Given the landscape in which it occurs, with further developments likely in agriculture, industry and housing, *E. granulatus* will remain a conservation issue. We have shown that it is no longer safe to assume that all burrows within its range are that species, so directly identifying the burrow occupant will be necessary through excavation of the burrow. Recent developments in eDNA techniques (Dawkins *et al.* 2024) offer the possibility of identifying burrow occupants from eDNA present in material ejected from the burrow. This technique shows great promise, but at this time it has not been used on Tasmanian burrowing crayfish. To implement it will require DNA sequencing of all the potential species. It is also worth noting that Dawkins *et al.* (2024) were only able to identify crayfish DNA in slightly over 50% of the burrows sampled, so surveys will need to sample large numbers of burrows. We strongly recommend the development and refinement of this approach for investigating Tasmanian burrowing crayfish.

The current endangered status of *E. granulatus* remains appropriate and there is no evidence that it could be downlisted under either the EPBCA or TSPA. Furthermore, its status on the EPBCA should be reviewed to assess whether it would qualify as Critically Endangered given its area of occupancy within its predicted range will be further reduced as a result of new records of other species of *Engaeus*. However, this would require further survey effort. At this time, no other species of *Engaeus* included in this paper warrant listing on either legislation. Although the

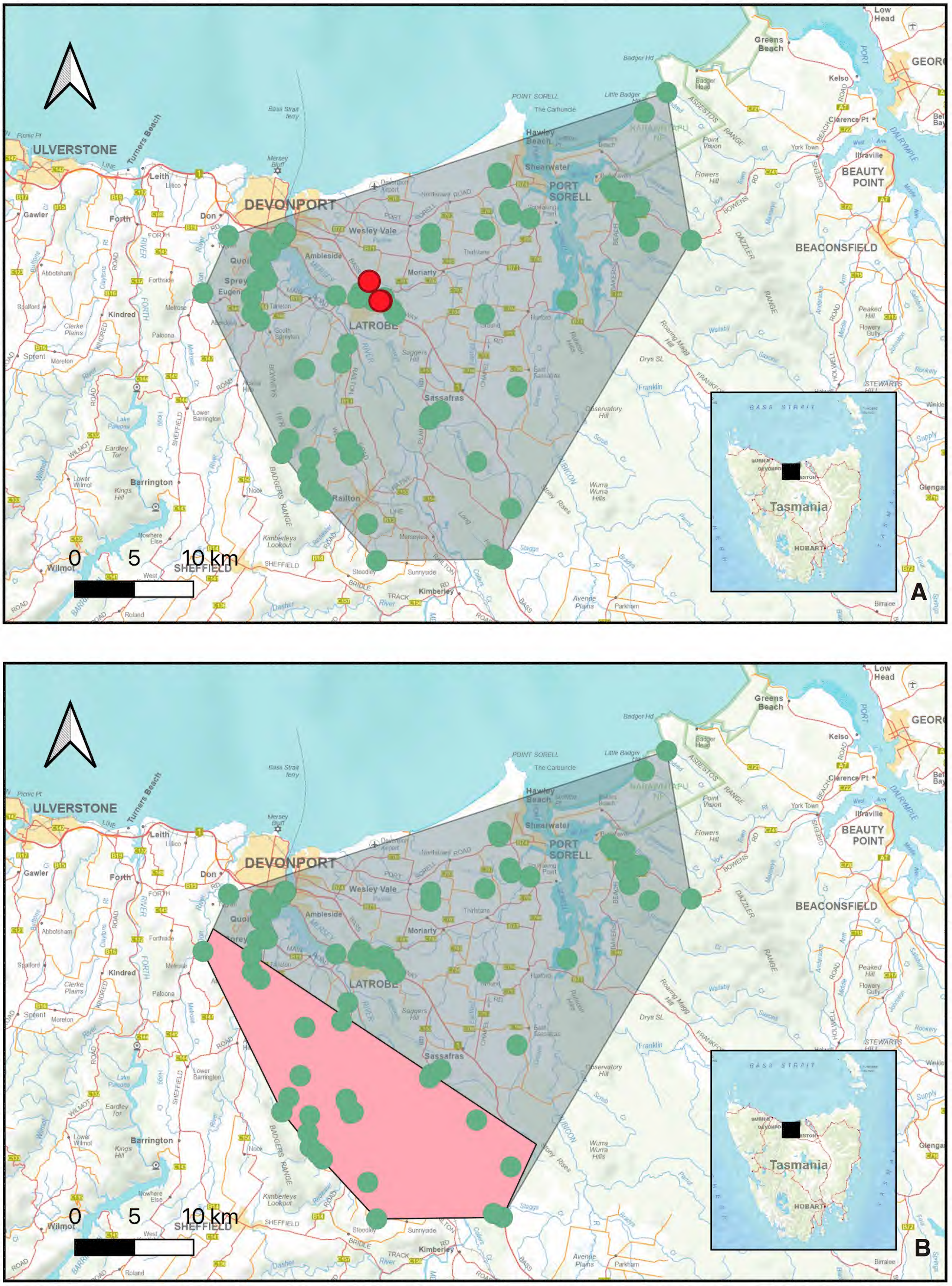

FIG. 2 — **A** Range of *Engaeus granulatus* and the two locations where *E. excavator* has been found (red dots). (Base map: ListMap). **B** Range of *Engaeus granulatus* overlapped by *E. fossor* (pink polygon) (Base map: ListMap).

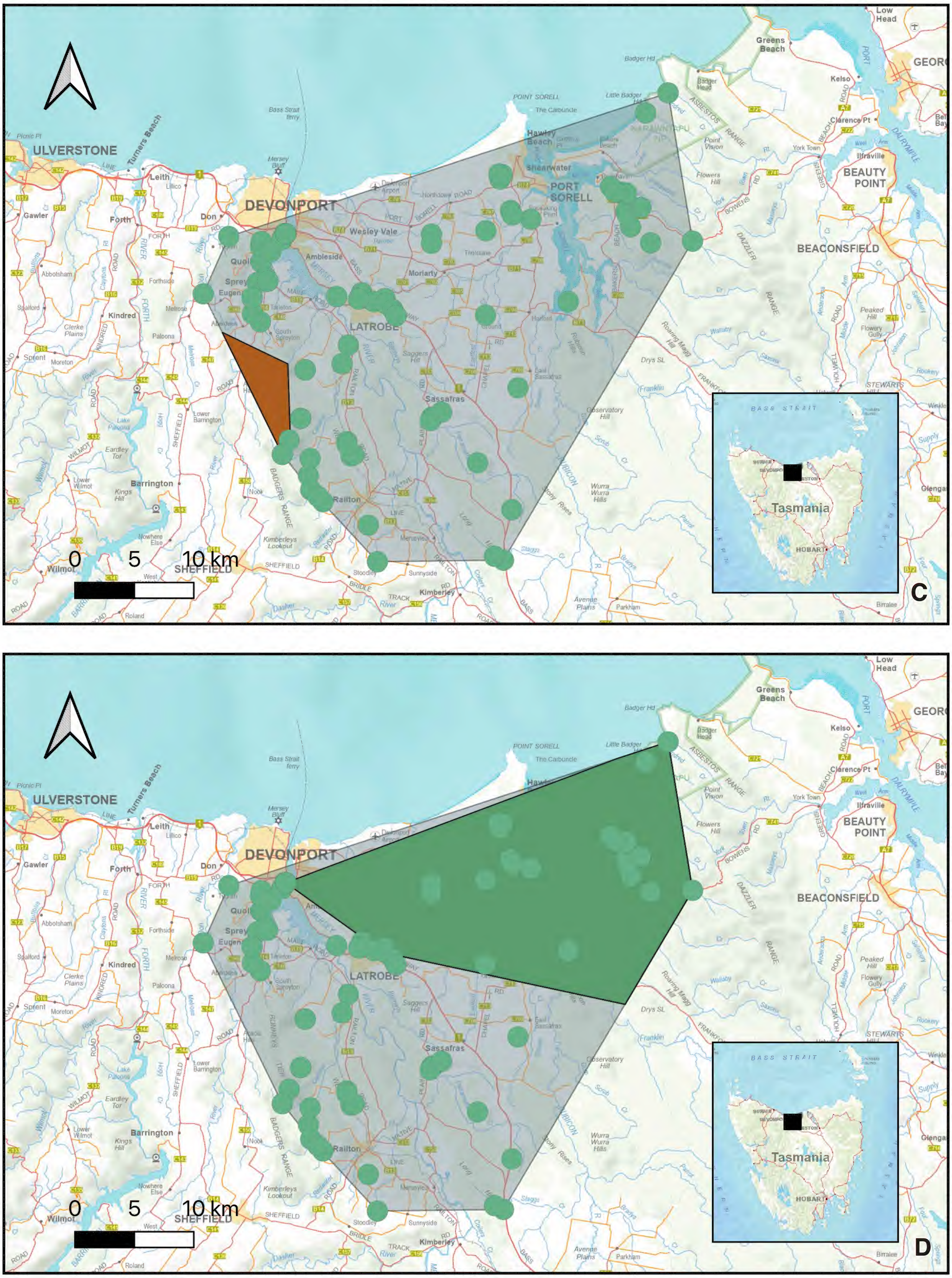

FIG. 2 — **C** Range of *Engaeus granulatus* overlapped by *E. cisternarius* (brown polygon) (Base map: ListMap); **D** Range of *Engaeus granulatus* overlapped by *E. mairener* (green polygon) (Base map: ListMap).

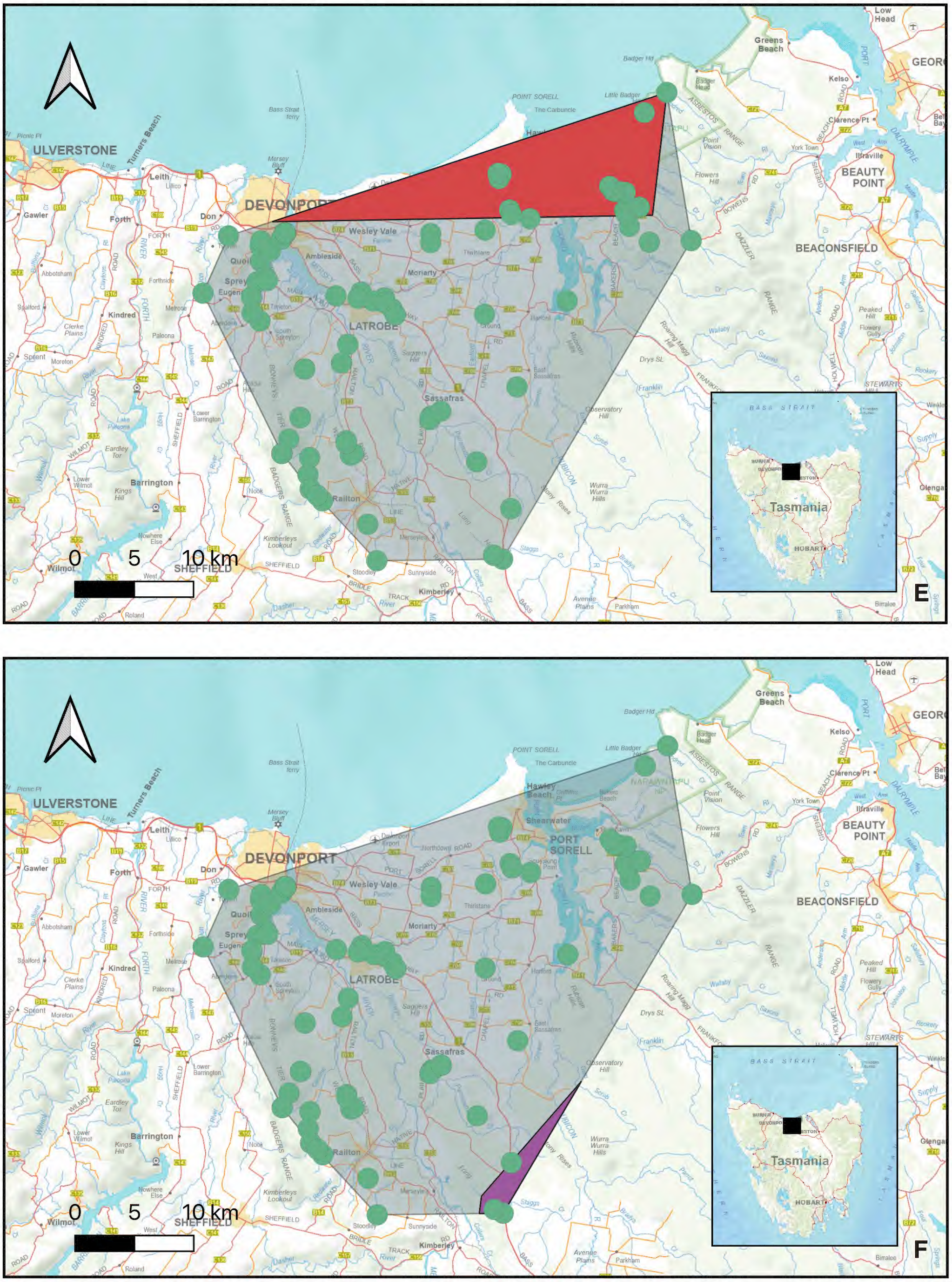

FIG. 2 — **E** Range of *Engaeus granulatus* overlapped by *E. cunicularius* (maroon polygon). The range of *E. cunicularius* is probably exaggerated by records further from the coast, outside the *E. granulatus* range to the east (Base map: ListMap). **F** Range of *Engaeus granulatus* overlapped by *E. nulloporius* (purple polygon) (Base map: ListMap).

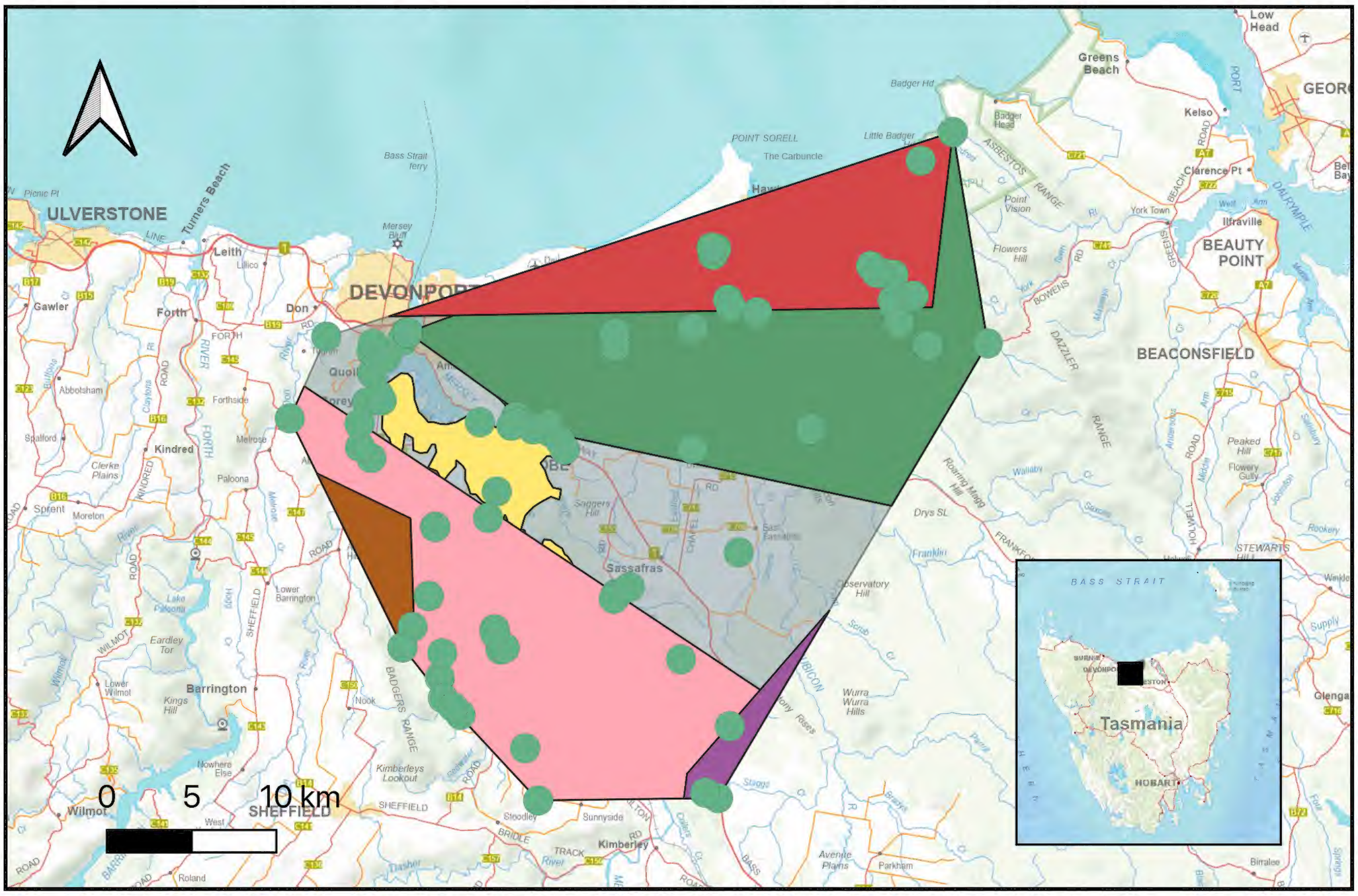

FIG. 3 — Range of *Engaeus granulatus* showing overlaps with other *Engaeus* spp.: *E. cisternarius* (brown), *E. fossor* (pink), *E. nulloporius* (purple), *E. mairener* (green) and *E. cunicularius* (maroon). The yellow polygon encloses land below 10 m asl, potential habitat for *E. excavator* (Richardson 2024). (Base map: ListMap).

current known range of *E. excavator* is very small, based on the conclusion of Richardson (2024) that without any further data on its range and area of occupancy, any assessment of its conservation status, beyond an informal assessment as data-deficient, is impossible. However, the possibility that *E. excavator* is a narrow-range endemic species must not be ignored, and we emphasise the need for an intensive survey to clarify its status, and in doing so provide clarification of the status of *E. granulatus* in a substantial part of its range.

Our results show that the management of *E. granulatus* is legislatively and practically more complicated than previously thought. The assumption that *E. granulatus* is the occupant of burrows within the current known range (i.e., the minimum convex polygon around apparently reliable records) is simply not tenable: at least six other species co-occur, to varying extents, with this species. This assumption almost certainly resulted in the recently-described *E. excavator* being overlooked. Since excavating burrows in dry paddocks without mechanical assistance involves many hours of work it is easy to see why surveyors might lean on the assumption that such burrows belong to *E. granulatus*, whereas they might equally belong to *E. excavator* or indeed *E. mairener.*

Under the EPBCA, activities that directly impact on the habitat of the listed *E. granulatus* may warrant referral under the Act or a permit under the TSPA. When burrows are present in an area, this can lead to long-term and complex approval conditions for a project, with considerable costs involved. In these cases, identifying the occupying species is a critical component of any management strategy. However, this comes with its own challenges. At present, excavation is the only way to identify the species present, an activity that in itself may be subject to both Commonwealth and State permit requirements, and one that is, at least in temporary terms, destructive. Under the TSPA, permits have been (and continue to be) issued under Section 51 (through the *Threatened Species Protection Regulations 2016*) to knowingly take specimens of a listed taxon. But there is a bootstrapping problem here: until a burrow is excavated and its occupant identified, there is no way of knowing whether it is a listed species, and thus whether a listed species has been 'knowingly taken'. Without direct evidence of the species present, this is almost certainly an untenable legal position. Similarly, under the Tasmanian *Nature Conservation Act 2002* (through the *Nature Conservation (Wildlife) Regulations 2021*), permits to take specially protected wildlife (which is how *E. granulatus* is listed) and products of the species (which is how burrows have been interpreted) are issued: again, under the potentially false assumption that the species involved is *E. granulatus*. This legal position taken by officers of the Department of Natural Resources and Environment Tasmania (NRE Tas) is probably tenuous – clearly until a successful excavation has occurred and a specimen is in hand, one does not 'know' if an action would impact a listed taxon. At least under

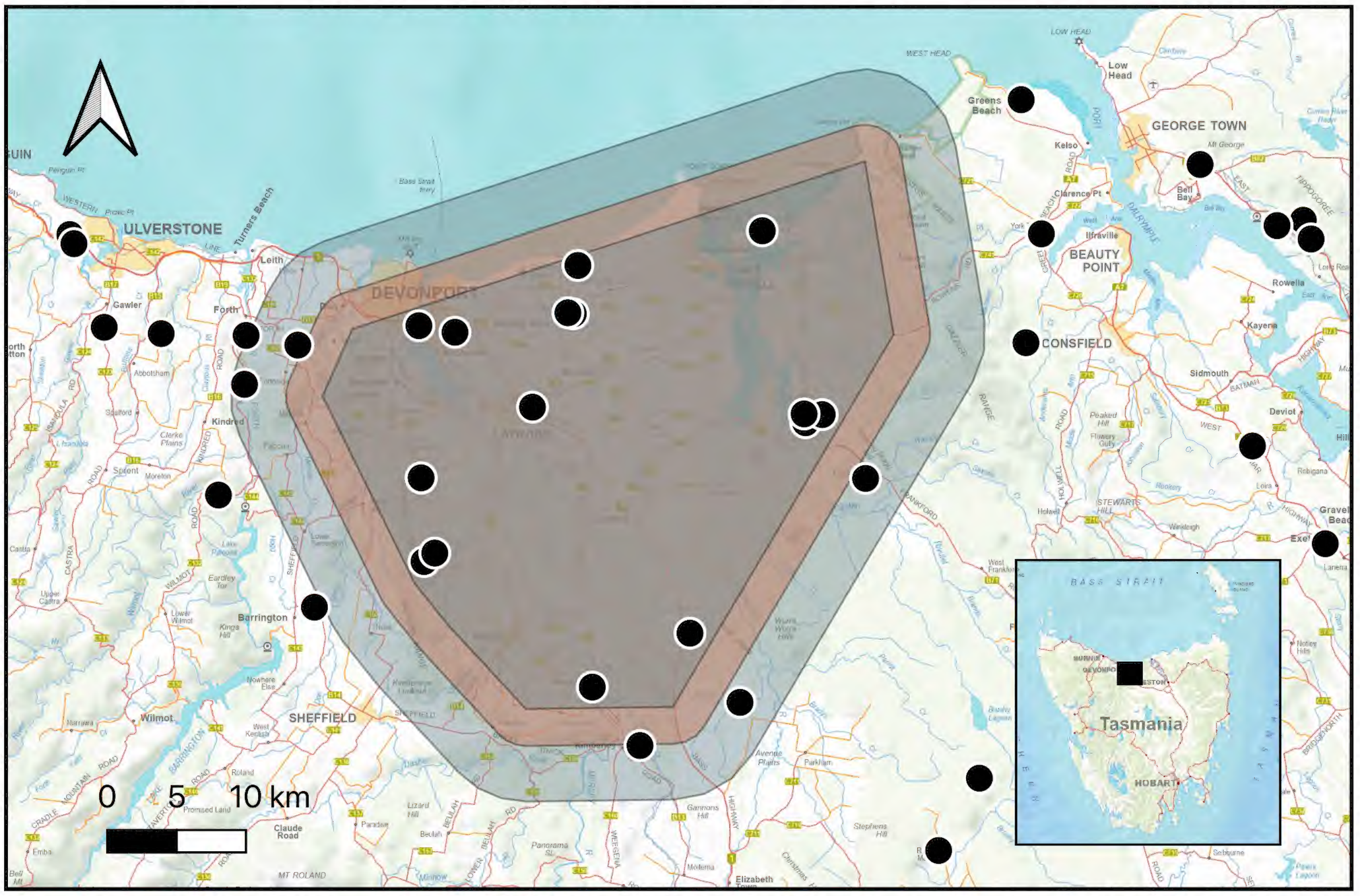

FIG. 4 — Range of *Engaeus granulatus* with 2 km and 5 km buffers, plus records of other *Engaeus* species (black dots) (Base map: ListMap).

Section 51 of the TSPA, 'a person must not **knowingly**, without a permit – (a) take, keep, trade in or process any **specimen of a listed taxon** of flora or fauna' (our emphasis added in bold). For the record, permits are also required for survey and handling of any members of the Parastacidae under the Tasmanian *Inland Fisheries Regulations 2019*.

We are aware of the potential implications of the findings presented here. No longer is assumption a valid approach to the management of a State- and Commonwealth-listed species of *Engaeus*. While excavation is certainly not a preferred survey option, at present it is the only viable one that yields results that can usefully inform management. Unfortunately, we also know that manual excavation is not always successful and mechanical assistance may be required (this is absolutely the case for *E. excavator*).

We urge all researchers and naturalists to ensure records of *Engaeus* are provided to the *Natural Values Atlas*, even if simply as *Engaeus* sp. (to alert land managers to the possible presence of a threatened species). It is imperative that the known and potential range boundaries of *E. granulatus* be updated regularly to ensure it is safeguarded during new and existing developments: all too often, this species has been overlooked due to lack of information.

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(accepted 13 August 2025)

SHARING A THYLACINE *THYLACINUS CYNOCEPHALUS*: ONE THYLACINE, FIVE SPECIMENS, FOUR MUSEUMS ON TWO CONTINENTS

by Kathryn Medlock

(with eight plates)

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As the largest marsupial carnivore of modern times and one of the most well-known recently extinct species, the thylacine, or Tasmanian tiger *Thylacinus cynocephalus*, continues to be a source of scientific interest and public fascination. Today, over 800 individual thylacine specimens are lodged in the world's museums, most acquired during the nineteenth and early twentieth centuries. This paper describes the process of tracking the fate of a single thylacine that was captured and killed in 1902 as an example of how, after entering the museum system, its remains were shared between researchers and institutions. Specimens obtained from this animal are now held in four natural history museum collections: three in Australia and one in Europe.
Key Words: thylacine, Tasmanian tiger, marsupial extinction, Australian Museum, Macleay Museum, Tasmanian Museum and Art Gallery.

INTRODUCTION

The thylacine, or Tasmanian tiger *Thylacinus cynocephalus*, is one of the most well-known recently extinct species. As the largest marsupial carnivore of modern times, specimens were (and still are) sought by museums around the world, and today, over 800 individual thylacine specimens are lodged in the world's museums. Most were acquired during the nineteenth and early twentieth centuries (S Sleightholme, pers. comm. 12 May 2024). As an example of a species the extinction of which was human-induced, these much-valued specimens provide a priceless window into the past and a lesson for the future about how easily a species may be exterminated and become extinct. Historical information associated with thylacine specimens provides humanities and scientific researchers with insights into the processes and events surrounding species rarity and eventual extinction. Distinct from the numerous alleged sightings since 1936 (death of the last live thylacine in the Hobart Zoo), there is no doubt that if reliably labelled, each specimen demonstrates existence prior to 1936. Those specimens, if associated with verified data from primary sources, provide a fundamental source of information from which species distributions and population changes can be assessed with a high degree of accuracy.

When natural history museums were being established and expanded during the nineteenth century, negotiating specimen acquisitions via purchase, collection, exchange and donation was a major task for most curators. With the aim of highlighting local fauna and newly discovered species in public displays, museum curators also aimed to provide scientists with specimens for study and the description and classification of newly discovered species. Prior to the recognition and establishment of environmental and ecological science, the collecting details for many specimens were not considered to be as important as they are today. Museums were more interested in recording acquisition dates and donors' names rather than the circumstances, date and place of collection. The person who captured and killed the animals, was rarely identified in early museum records, but the donor was. People who were encouraged to donate specimens were informed that their names would be permanently and prominently attached to their specimens. Although a specimen could pass through several hands on its way from the field to the museum, the donor's role was always given prominence in museum records (Alberti 2005).

Only a frustratingly small number of the thylacines lodged in museums have a reliable and complete provenance. Thylacine researcher Dr Stephen Sleightholme (compiler of the International Thylacine Specimen Database) estimates that only about 14% of all specimens currently have an assigned date and place of collection. From the 1920s the percentage of specimens with good provenances is higher due to a new research focus on the years of serious population decline in the lead up to extinction (S Sleightholme, pers. comm. 20 May 2025).

Discovery and retrospective assignment of accurate provenance data require a substantial amount of research but can render much new knowledge and significantly increase the value of any museum specimen by providing irrefutable proof of a species existence in time and place. Therefore, data sets using material with accurately provenanced associated data increases the significance, integrity, scientific and cultural value of those datasets (Fearing *et al.* 2025).

This paper describes the process of tracking the fate of a single thylacine that was captured and killed in 1902. After entering the museum system, its remains were shared between researchers and museums. Specimens obtained from this animal are now held in four natural history museum collections: three in Australia and one in Europe.

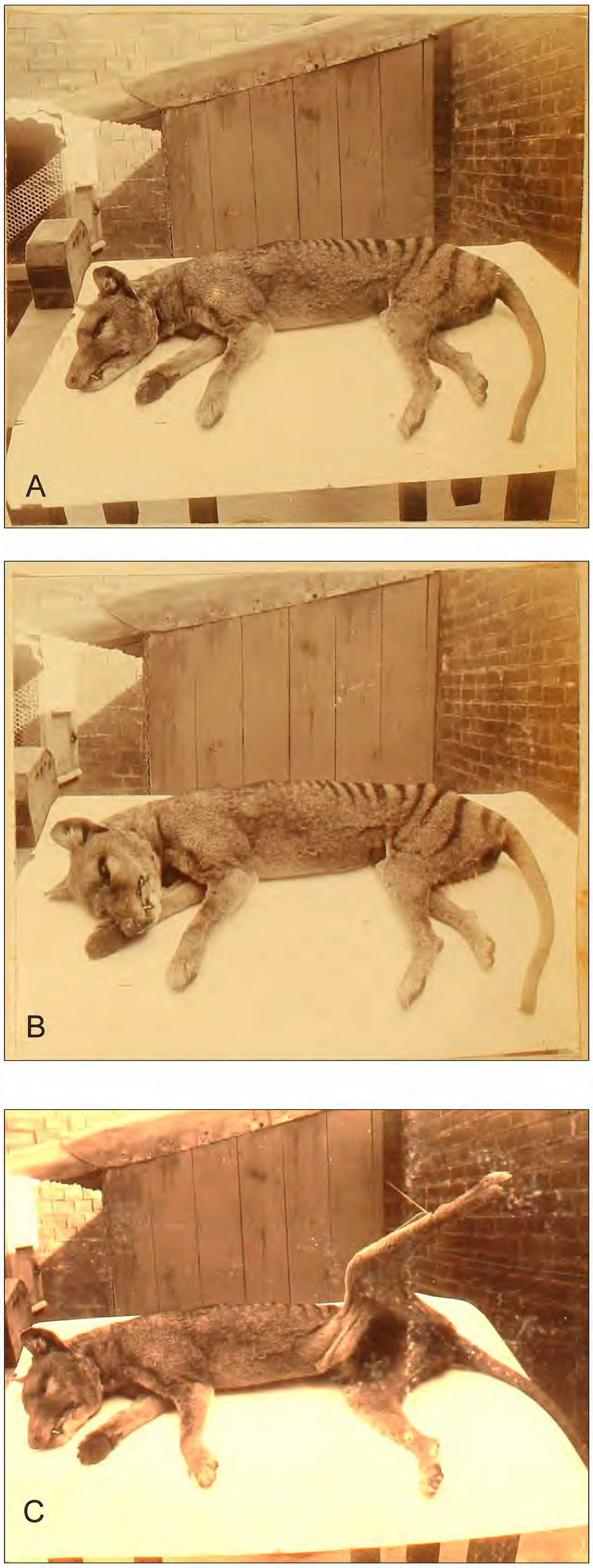

PLATE 1 — Adult female thylacine later prepared as a mounted specimen. **A** Thylacine's head has been positioned to reveal a severe injury across the front of the neck just below the jawbone; **B** General view of the animal laid on its right side; **C** Thylacine with its left hind leg elevated and held with a rope to give a clear view of her dissected pouch area. (Images © 2025 Australian Museum. AMS421-3-p5)

THE SEARCH

This search for information began with the 2011 discovery by Australian Museum archivists of three unpublished photographic prints of a dead female thylacine. The photographs were found during a reorganisation of the photographic collection involving the registration of a series of photograph albums that, before their transfer to the museum archives, had been held in curatorial offices. The albums, containing photographs of a range of specimens that had been acquired by the museum, were introduced at a time when photography was first seen as a useful tool to assist curators to keep track of collections and specimens.

The three photographs depict a mature adult female thylacine (pl. 1A, B, C). The animal was identified by Dr Sandy Ingleby as Australian Museum mounted specimen M1674 that had been acquired from the University of Sydney via Professor Haswell, a museum trustee (S Ingleby, pers. comm. 31 May 2021). The photographs prompted this research into the story of the animal, the source of the photographs and the circumstances of this thylacine's acquisition by the Australian Museum. During the search, a paper trail was discovered that led to the identification of additional specimens obtained from this animal that are now lodged in separate museums. An approximate collecting date and a clue to the collecting locality were also discovered.

THE PHOTOGRAPHS

The dead female thylacine is positioned on her right side on what appears to be a work bench. The background consists of the internal corner of a brick wall with some small basic animal cages, of the sort that was common in laboratories at that time. In each photograph, the thylacine's body has been slightly re-arranged to more clearly show some features of the animal.

- Plate 1A (AM AMS421_3_p.5_[a]) the thylacine's head has been positioned to reveal a severe injury across the front of the neck. This injury may have been caused by a 'necker' snare which generally consists of a running noose placed at head height across a game trail or gap in a fence (Jetson 1998), strangling the captured animal.
- Plate 1B (AM AMS421_3_p.5_[b]) is a general view of the animal laid on its right side.
- Plate 1C (AM AMS421_3_p.5_[c]) shows the thylacine with her left hind leg elevated and held with a rope to give a clear view of her dissected pouch area.

These images were originally held in an album that also contained photographs of galleries at the Tasmanian Museum (now Tasmanian Museum and Art Gallery TMAG). The photographs can be reliably dated to 1901/1902 when a new gallery known as the Trophy Room was formed by enclosing a central courtyard. The building work was completed in early 1902 but the new Trophy Room was not opened to the public until later in the year. A photograph of the new gallery depicts it during the installation of exhibits prior to opening to the public

towards the end of 1902. Other photographs in the same album depict a new art gallery that was built at the same time but opened to the public in April 1902.

The photographs depict what is now a taxidermied thylacine mount prior to preparation, and was identified by Dr Sandy Ingleby, collection manager for mammals at the Australian Museum (S Ingleby, pers. comm. 31 May 2021). A curatorial note dated 23 January 2012 that is kept with the specimen, states there had been damage to the ear tips and that some skin patches were repaired using kangaroo skin. The acquisition date was recorded as 5 August 1902 and the specimen is listed as being donated 'in flesh' (Australian Museum, curatorial note, 23 January 2012). The donor was Professor William Haswell, a University of Sydney biology professor, and a trustee of the Australian Museum. The collection date and collector were not recorded for the usual reasons as outlined previously.

All three images were subsequently published on the online news website YAHOO!news on 27 August 2024. The YAHOO!news article suggested that the thylacine had come from Melbourne and may be one of three thylacines that died at the Melbourne Zoo in that year. It was suggested that the photographs were taken soon after death because there is no sign of rigor mortis and the thylacine was able to be manipulated into the three different positions. This led to the conclusion, in consultation with thylacine researcher Branden Holmes, that the thylacine had died only moments before the photographs were taken (Dahlstrom 2024). However, rigor mortis resolves over time due to muscle decomposition and can be overcome by physical manipulation of joints. In dogs, for example, rigor mortis is present at less than one day after death and can persist for around seven days at a temperature of 11°C (Brooks 2016). Whilst working at the TMAG, the author dissected and prepared hundreds of Tasmanian birds and mammals as scientific specimens. Extensive rigor mortis was very rarely encountered, a fact that was corroborated by staff who carried out similar work for the Queen Victoria Museum and Art Gallery in Launceston (T Gordon, pers. comm. 1 July 2025). It is well known that rigor mortis is not present in de-frosted carcasses regardless of their state when initially frozen (N Mooney, pers. comm. 1 June 2025). It is highly likely that the thylacine was frozen as a preservation measure prior to being transported to Hobart and then shipped from Hobart to Sydney.

The claim that the specimen could be one of three thylacines that died in Melbourne Zoo on 9 April, 29 May and 9 June 1902 respectively is also highly questionable because the fate of the bodies of those three zoo animals is reliably known. The thylacines that died on 9 April and 29 May 1902 were sent to the National Museum of Victoria where their skins and some skeletal components were preserved as specimens C5741 and C5744 respectively and are still in the collection. The body of the third thylacine, which died on 9 June, was considered too damaged and therefore unsuitable for museum purposes and was destroyed at the zoo (Paddle 2012, 2017).

The first museum record of this entire thylacine specimen occurs in the handwritten register of specimens in the Tasmanian Museum and Art Gallery, the TM2 Register (1890–1913). Working retrospectively from this record, the provenance and fate of the thylacine's body was determined through examination of archival records held in the TMAG as well as the Australian Museum in Sydney.

THE TASMANIAN MUSEUM AND ART GALLERY

In mid-1902 the Tasmanian Museum (now TMAG) received an adult thylacine with two late-stage young in her pouch. Curator Alexander Morton retained and registered both pouch young into the TMAG collection and documented their acquisition in the museum's handwritten TM2 register. They were assigned the registration numbers TM10954 and TM10955. Dr Walter Henry Tofft, a municipal warden and medical doctor from Campbell Town was listed as the donor (pl. 2A). The entry was dated July 1902, but no specific day was given.

Although the two young thylacines were formally registered into the TMAG collection, their mother was not. Morton had already organised for her body to be sent to Professor William Haswell at the University of Sydney. The acquisition and subsequent donation of the thylacine to Haswell was not recorded in the TMAG Trustee Minutes but was noted in the TMAG register with an annotation alongside the registration entries for the pouch young: 'These two young tigers were taken from the pouch. The mother was sent to Prof. Haswell at The University of Sydney for dissecting purposes.' (TM2 register, July 1902, p. 273, pl. 2B).

Morton and Haswell had much in common, knew each other, and their interests overlapped. Prior to moving to Tasmania, Morton had worked at the Australian Museum when Haswell was the Acting Curator in 1883–1884. Haswell later became a Trustee of the Australian Museum from 1891 until 1923 (Strahan 1979, p. 166) and Morton was the Curator of the Tasmanian Museum from 1886 until 1907 (Huxley 2008). Both were active members of the Australian Association for the Advancement of Science (AAAS). Alexander Morton was a member of the Tasmanian Fisheries Commission (Morison 1983, Huxley 2008), and Haswell, as a well-respected marine biologist, frequently visited Tasmania on fisheries business.

After removing and preserving the pouch young, Morton sent the mother to Haswell in Sydney. Although Haswell had little interest in the thylacine, his work with the Australian Museum and as a comparative anatomy lecturer at the University of Sydney explains his interest in obtaining the thylacine for research and for student demonstration.

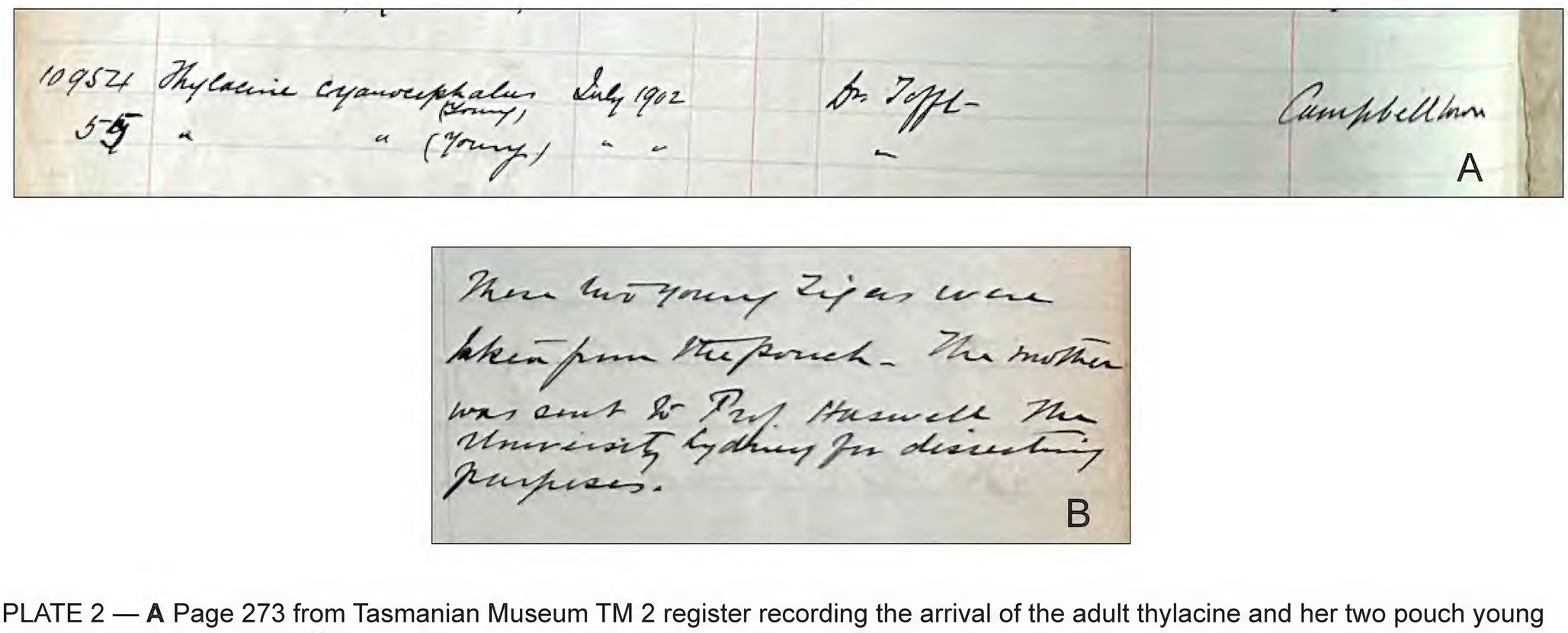
10952 Thylacinus cynocephalus (Young), July 1902 Dr Tofft- Campbelltown
5-5 " " (Young) " "
A
These two young Tigers were taken from the pouch. The mother was sent to Prof. Haswell The University Sydney for dissecting purposes.
B

PLATE 2 — **A** Page 273 from Tasmanian Museum TM 2 register recording the arrival of the adult thylacine and her two pouch young from Dr Tofft in July 1902; **B** handwritten note on opposite page of register 'These two young tigers were taken from the pouch. The mother was sent to Prof Haswell University of Sydney for dissection purposes.' (Images courtesy Tasmanian Museum and Art Gallery.)

TRANSFER TO PROFESSOR HASWELL, PHOTOGRAPHY AND PREPARATION

After the adult thylacine arrived in Sydney, Haswell transferred it to the Australian Museum for preparation. The transfer was organised through the Australian Museum's formal exchange program. This ensured that the University of Sydney acquired the thylacine's skeleton, and that the Australian Museum kept the skin for preparation as a mounted specimen. After arrival at the Australian Museum, Dr James Peter Hill, a University of Sydney biology demonstrator and embryology lecturer (Young *et al.* 1984), visited the Australian Museum, examined the thylacine, recording the size and extent of the pouch in his notebook and dissecting out the reproductive tract.

It is thought that the photographs (pl. 1A, B, C) were taken at the Australian Museum during Hill's visit for several reasons. Firstly, the Australian Museum routinely photographed new acquisitions, and secondly there is no part of the Tasmanian Museum building complex of 1902 with such an inside corner and matching brickwork. Nor did the Tasmanian Museum keep animals alive in cages such as those that can be seen in the photographs. The photographs were taken after the reproductive tract dissection, but before preparation of the mount, and were possibly taken in the taxidermist's work area.

After Hill dissected the thylacine, he labelled and preserved the reproductive tract with the rest of his collection, giving it the registration number of MA840. Hill's research specimens, including the thylacine reproductive tract, were subsequently taken to London when he moved there in 1906 (Richardson & Narraway 1999, Hughes 2000). Over his career, Hill published extensively on the embryology of marsupials, but he never personally published any research based on this thylacine specimen.

THE AUSTRALIAN MUSEUM

Prior to arriving at the Australian Museum on 5 August 1902, Haswell had already brokered the exchange deal with the approval of the museum's Curator (Director) Dr Robert Etheridge. The document regarding the exchange records that the Australian Museum would retain the skin and skull for preparation as a taxidermic mount for public display and that the post-cranial skeleton would be returned to the University of Sydney. The details are recorded in the Australian Museum Exchange Schedule No.32 of 1902 that records its arrival as 'Tasmanian Wolf in flesh' (pl. 3A). Etheridge wrote on the document: 'I have the honour to recommend this Exchange'. (Australian Museum Exchange document No. 32. of 1902.)

The Mounted Specimen

The exchange document records the new Australian Museum registration number, M1674. The specimen, a taxidermic mount, is still in the Australian Museum mammal collection and is known to staff as 'Haswell's Thylacine' (S Ingleby, pers. comm. 31 May 2021). The skull is retained within the mount museum.

Curatorial notes prepared later and dated January and February 2012 confirm its arrival date of 5 August 1902, and the existence of the three black and white photographs. As a group, the photographs are given the reference number AMS421/3/p.5. The banding pattern of the thylacine in the images aligns with the bands on mount M1674 (Haswell's thylacine). It is well known that individual thylacines each have a unique banding pattern that can be used to identify individual animals (Guiler 1985, Sleightholme & Campbell 2019), hence, the matching banding pattern provides further confirmation of the identification of the photographed animal.

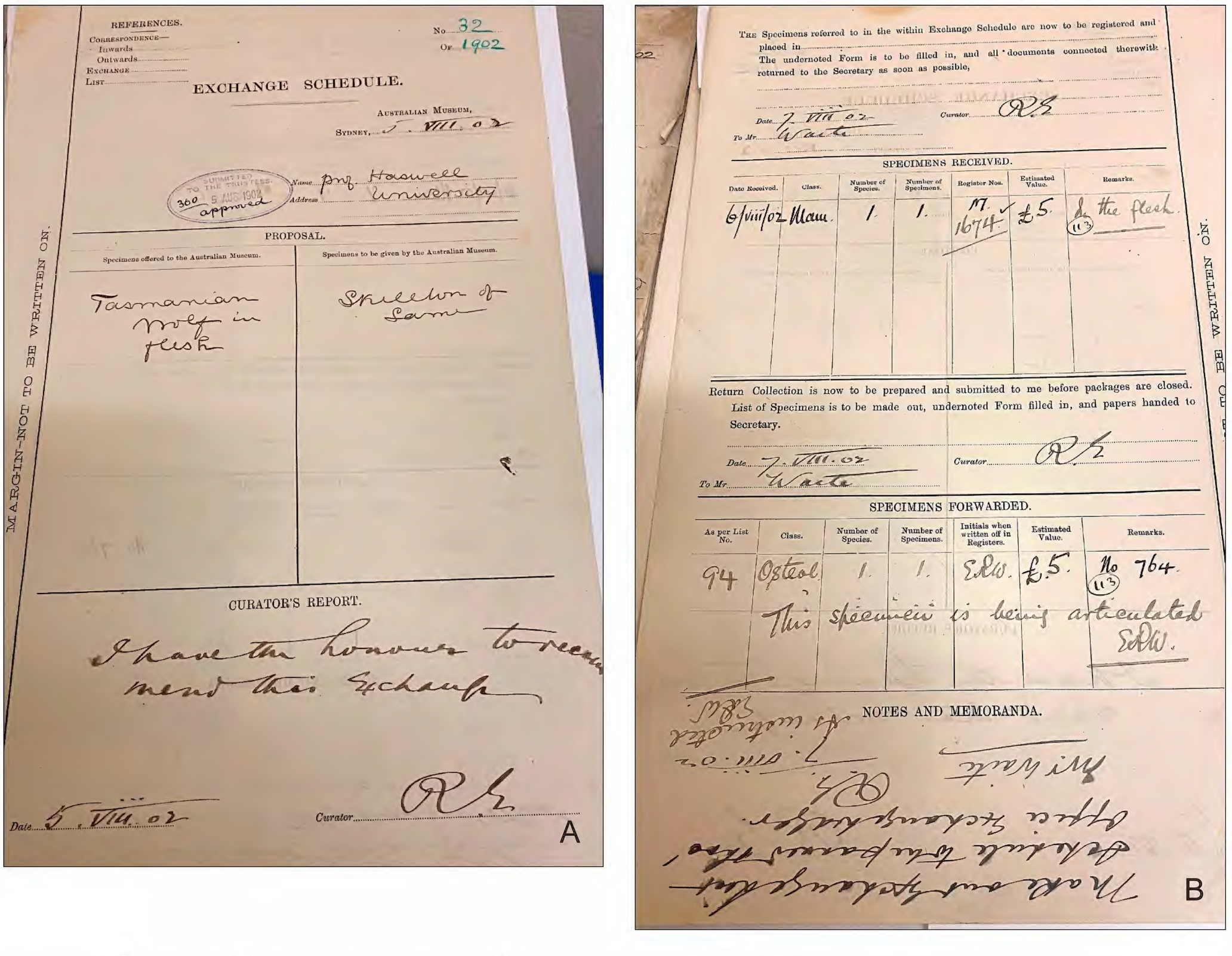
REFERENCES.
CORRESPONDENCE—
Inwards
Outwards
EXCHANGE
LIST
No 32
OF 1902
EXCHANGE SCHEDULE.
AUSTRALIAN MUSEUM,
SYDNEY, 5 VIII 02
SUBMITTED TO THE TRUSTEES. 360 5 AUG 1902 approved
Name Prof. Haswell
Address University
PROPOSAL.
Specimens offered to the Australian Museum.
Specimens to be given by the Australian Museum.
Tasmanian wolf in flesh
Skeleton of same
CURATOR'S REPORT.
I have the honour to recommend this Exchange
Date 5. VIII. 02
Curator R Z
A
MARGIN-NOT TO BE WRITTEN ON.
THE Specimens referred to in the within Exchange Schedule are now to be registered and placed in
The undernoted Form is to be filled in, and all documents connected therewith returned to the Secretary as soon as possible,
Date 7. VIII. 02
Curator R Z
To Mr Waite
SPECIMENS RECEIVED.
Date Received. 6/VIII/02
Class. Mam.
Number of Species. 1.
Number of Specimens. 1.
Register Nos. M 1674
Estimated Value. £5.
Remarks. In the flesh (113)
Return Collection is now to be prepared and submitted to me before packages are closed. List of Specimens is to be made out, undernoted Form filled in, and papers handed to Secretary.
Date 7. VIII. 02
Curator R Z
To Mr Waite
SPECIMENS FORWARDED.
As per List No. 94
Class. Osteol.
Number of Species. 1.
Number of Specimens. 1.
Initials when written off in Registers. E.R.W.
Estimated Value. £5.
Remarks. No 764 (113)
This specimen is being articulated E.R.W.
NOTES AND MEMORANDA.
B
MARGIN-NOT TO BE WRITTEN ON.

PLATE 3 — **A** Australian Museum exchange schedule No. 32 of 1902 recording the arrival of 'Tasmanian wolf In flesh' to be exchanged with 'skeleton of same'; **B** reverse of exchange document No. 32 of 1902 accepted by zoology staff member ER Waite and recording the new registration number of M1674. The body and the skeleton were both valued at £5, and the skeleton is to be articulated. (Author's photographs.)

The Skeleton, Macleay Museum

The exchange document (pl. 3A, B) also records the fate of the post-cranial skeleton and its subsequent delivery to the Macleay Museum, University of Sydney. The arrangement was signed off by the museum zoology assistant, Mr ER Waite, who added and initialled a note to explain why the skeleton wasn't immediately available: 'As the specimen is being mounted it will not be ready until next month. E.R.W.'

A later, but unsigned note on the same document records the delivery of the skeleton to the university on 28 October 1902: 'Specimen delivered to Prof Haswell's messenger 28/10/02'.

It is unusual for an incomplete mammal skeleton, especially one missing a skull, to be an acceptable scientific museum specimen. The University of Sydney already had a fully mounted thylacine and several skulls that had been sent to the university by Tasmanian scientist William Petterd in 1876. The only type of thylacine specimen lacking in the University of Sydney teaching collection in 1902 was a complete articulated skeleton. A complete skeleton was valuable because it could give comparative anatomy students the opportunity to study all details of thylacine osteology and examine the similarities and differences between marsupial and placental skulls and post-cranial morphology, characteristics of great interest to anatomists and evolutionary biologists.

This was not the first time that a different skull was used to 'complete' a thylacine skeleton. When sending a skeleton to Cambridge University in 1869, thylacine trader and Hobart solicitor Morton Allport wrote:

> *I regret that I could only obtain one small Thylacinus for this shipment but will make up for it shortly. The skull of the specimen sent was much maltreated by the Shepherd who killed the beast and fearing it may prove difficult to repair I have added a perfect skull from my own cabinet.* (Allport 1869)

The post cranial articulated skeleton from Haswell's thylacine is currently held in the Macleay Museum at the University of Sydney (M498). For display purposes, a different skull (M1427), probably one that was acquired from Tasmanian scientist William Petterd, is often placed on the skeleton for 'completeness'.

SPECIMEN DETAILS

After its death, the possession of this thylacine passed through many people each of whom had a role in determining its fate and ensuring that its parts were formally lodged in four museum collections: three in Australia and one in Europe. This thylacine went from being a living entity, integral to Tasmania's natural environment, to a valued scientific specimen for museum curators and scientists to examine, skin, measure, photograph and dissect. With each transaction, the specimens were valued according to the agendas and the needs of the museums and universities that preserved and held on to the material.

The following is a summary of the 'afterlife' of each anatomical specimen obtained from this thylacine.

Pouch young (male): A930 (pl. 4).
Pouch young (female): No longer exists
Tasmanian Museum and Art Gallery, Hobart

On arrival at TMAG, the male and female pouch young were removed from the pouch and retained by the museum and preserved as spirit specimens. Each was registered separately with the numbers TM10954 and TM10955. The register entries do not record which number was assigned to the male and which to the female. Both were received from Dr Walter Tofft dated to July 1902 and registered by Alexander Morton on arrival. The female pouch young no longer exists, but its fate can be determined by examination of the TMAG Trustee Minutes.

In October 1910, Dr TT Flynn, the newly appointed biology professor at the University of Tasmania, asked for the 'immature specimens of the Thylacine now in the store at the Museum' (Trustee Minutes 10 October 1910). The decision was deferred until the next meeting when Flynn's request was granted because 'The specimen was needed for research work' (Trustee Minutes 21 November 1910).

Four months later, in March 1911, Flynn again approached the trustees via fellow trustee, the geologist and engineer Dr Fritz Noetling, who wrote a letter asking, on Flynn's behalf, to use the remaining male pouch young. After some discussion, the Trustee Minutes record that:

> *A letter from Dr Noetling with regard to an embryo of Thylacine was read. As it earned the action of the Trustees and needed a reply from the Secretary and Curator, this reply was read.*
> *The Chairman as well and Mr Thomas Steele informed the meeting that the Thylacine was still a plentiful animal in certain parts of the country.* (Trustee Minutes 6 March 1911)

Soon after this, Flynn changed his mind regarding the second specimen, the trustees recording on 19 March 1911 that Flynn's request had been withdrawn (Trustees Minutes 19 March 1911).

PLATE 4 — A930, the surviving male pouch young. This was one of two young that were removed from their mother's pouch and retained by the Tasmanian Museum. Its female sibling no longer exists. (Image courtesy Tasmanian Museum and Art Gallery.)

In 2018 the male pouch young (A930) (pl. 4) was taken to Melbourne University for scanning as part of a research project to examine development in the thylacine. The specimen (along with pouch young representing a range of ages from other museums) was CT scanned, its age estimated, and skeletal and organ development was revealed. Specimen A930 was estimated to be 9.5 weeks old, with a light covering of fur and showed the distinct thylacine elongated skull with a high degree of ossification. The previous lack of non-invasive techniques to examine rare museum specimens had limited studies on the development of thylacines at this early age (Newton 2018).

PLATE 5 — M1674 Haswell's thylacine mounted in 1902. (Image Sandy Ingleby, © 2025 Australian Museum.)

Mounted specimen of Haswell's thylacine with skull in skin M1674. Australian Museum, Sydney

After the body was received at the University of Sydney, it was sent to the Australian Museum as part of a formal exchange agreement authorised by museum director Robert Etheridge. After mounting by the museum taxidermist, the specimen has often been on display (pl. 5).

Post cranial articulated skeleton of Haswell's thylacine M498 Macleay Museum, University of Sydney.

This skeleton was retrieved from the Australian Museum specimen M1674 during its preparation as a mounted specimen. The skull was retained within the mount. This partial skeleton is usually displayed with an unrelated skull M1427 positioned to depict a complete thylacine skeleton (pl. 6).

Dissected reproductive tract: MA 840. Series of 200 microscope slides: MS 464 JP Hill Collection, Museum für Naturkunde, Berlin.

Initially, the dissected reproductive tract was kept in Hill's collection at the University of Sydney. Hill left the university in 1906 for a position at University College London taking his research specimens, photographs, field notebooks and microscope slides (pl. 7A) with him. He remained in London until 1966 when these items were transferred (on permanent loan) to the world-renowned Hubrecht Collection at the Netherlands Institute for Developmental Biology in Utrecht (Richardson & Narraway 1999). In 2004, the Hubrecht Collection was transferred to the Museum für Naturkunde in Berlin.

In August 1980, the dissected reproductive tract was discovered by University of Queensland marsupial reproduction researcher Dr R Leon Hughes at the Hubrecht Laboratory in the Netherlands (pl. 7B). A label (transcribed below) held in the specimen jar recorded the collecting date as '5.VIII.02', and after finding an entry in Hill's 1902 Dasyurus notebook (pl. 8), the provenance along with Hill's original observations on the specimen, were discovered:

THYLACINUS CYNOCEPHALUS female from A Morton Hobart Rec. 5.viii.02	
Pouch	greatest length (interior). 20.5 cms
	greatest breadth. 19 cms
Aperture of pouch	11 x 8 cms directed down and back
4 teats	2 large anterior right with length of 5.5 cms, left with length of 5 cms
	2 small posterior

PLATE 6 — MM M.498, articulated skeleton (M498) from Haswell's thylacine with unrelated skull. The skull was retained in the mounted specimen, so the skeleton is usually displayed with an unrelated skull (M1427) to make it look 'complete'. (Image Macleay Museum, University of Sydney.)

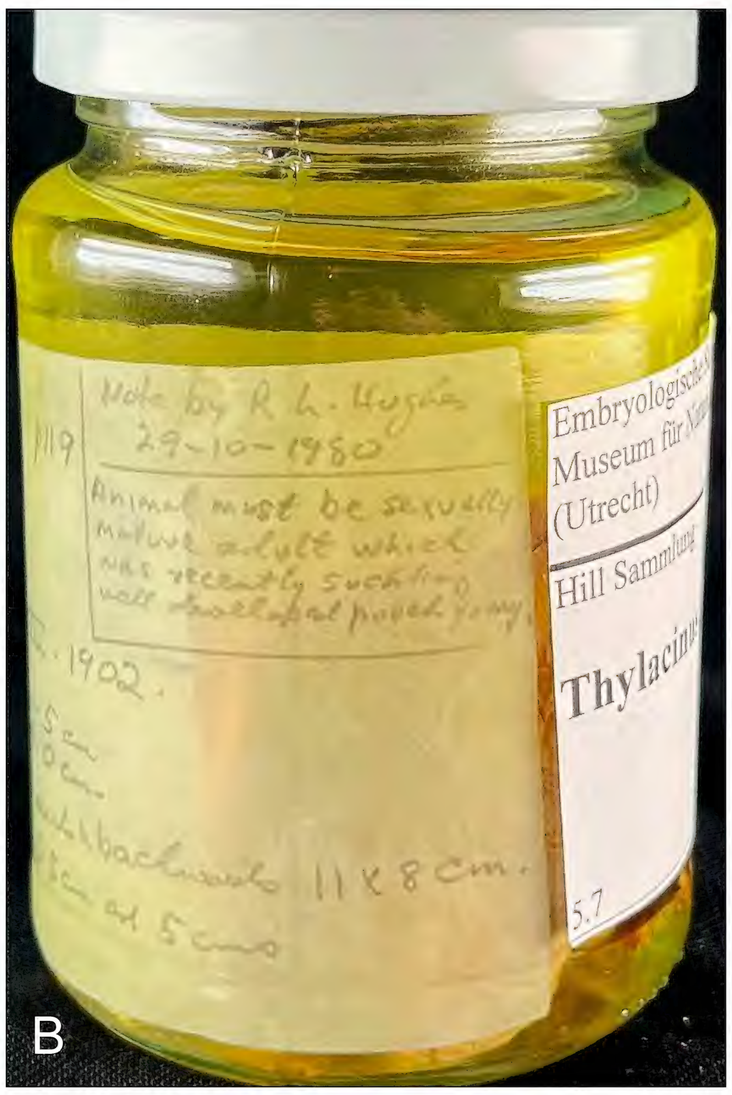

PLATE 7 — **A** Microscope slides prepared by R Leon Hughes in 1980 from JP Hill's specimen dissection MS 464; **B** Reproductive tract of specimen MA 840. (Images Fiona Mohrle, Universität Potsdam)

The notebook also records the existence of a much earlier specimen that had been held in the Hunterian Museum at the Royal College of Surgeons in London obtained from an animal that died in London Zoo in January 1870. It was a preserved preparation of female organs of *Thylacinus* recorded as: '2734 I (Hunterian Institute 9.2.77). Female organs of Thylacine (*T. cynocephalus*). Adult female received 27 January 1870. Zoological Gardens.' This specimen no longer exists. It was destroyed during a bombing raid in 1941 (Hughes 2000).

The focus on pouch morphology recorded in Hill's notebook validates the view that Hill was involved in the dissection and may have organised for the mother to be photographed after dissection, but in a way that reveals the pouch area. When the reproductive tract was examined by Hughes in 1980, he noted that it had been roughly dissected out, along with the entire urogenital system, including the cloaca and surrounding fatty mesenteries (Hughes 2000).

The photograph of the thylacine with its leg raised (pl. 1C) was enhanced but not altered to enable better examination of the pouch area and the dissection. This was done by zoologist Tammy Gordon who is familiar with marsupial gross anatomy and has over 30 years of experience dissecting and handling mammals at the Queen Victoria Museum and Art Gallery in Launceston. Her report states that:

> *… the area around the pouch has been opened up and some deeper internal structures have been removed. At the bottom of the image what appears to be the inner surface of the pouch can be seen with nipples (two large and two small). Towards the top of the image is a groove surrounded by outward facing hair that could be the actual aperture of the pouch.* (T Gordon, pers. comm. 5 July 2025)

The rough nature of this dissection clearly damaged the pouch structure and may explain why there is little evidence of a pouch in the mounted specimen.

In 1980, Hughes examined the dissected specimen in detail and published his findings in the *Australian Journal of Zoology* (Hughes 2000). He noted that the general plan of the reproductive tract followed that of other marsupials, only differing in several details from that described by Pearson and De Bavay (1953) who had based their descriptions on more immature and less well-preserved pouch young. Hughes' microscope slides prepared from his dissection are now held with the specimen in Berlin but registered separately with the number MS464. Hughes' research and dissection of the specimens found that the animal was in a state of anoestrus, had two young, and was probably in the terminal lactation phase of a cycle (Hughes 2000).

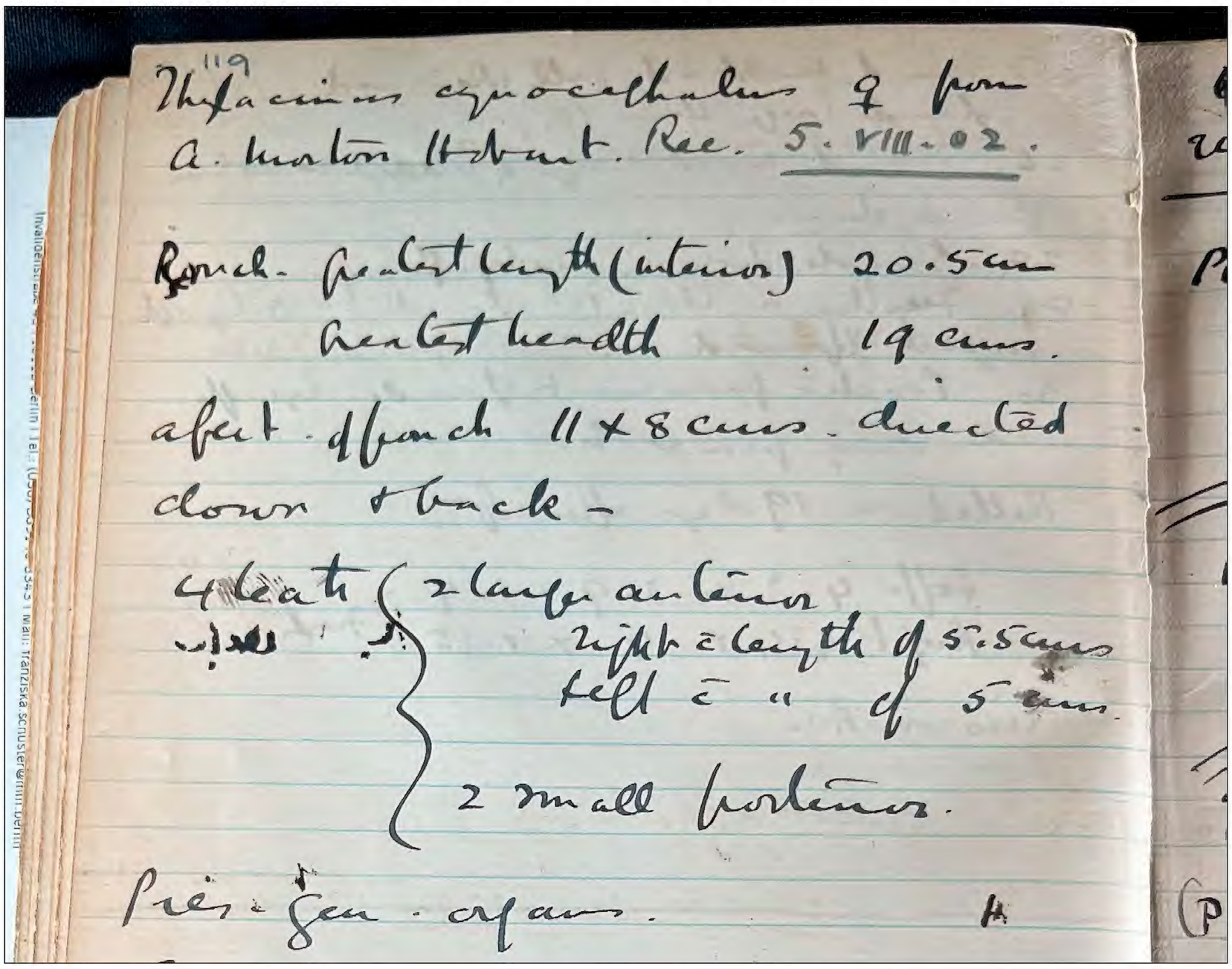
119
Thylacinus cynocephalus ♀ from
A. Morton Hobart. Rec. 5. VIII. 02.
Rough. Greatest length (interior) 20.5 cm
Greatest breadth 19 cms.
afect. d pouch 11 x 8 cms. directed
down & back –
4 teats (2 large anterior
right & length of 5.5 cms
left " " of 5 cms.
2 small posterior.
Prés. Gen. organs.

PLATE 8 — A page from JP Hill's notebook records that the adult female thylacine had been acquired from Alexander Morton on 5 August 1902. (image Fiona Möhrle, Universität Potsdam)

WAS THIS A BOUNTY ANIMAL?

The thylacine was sent to the Tasmanian Museum by Dr Walter Tofft, the municipal warden for Campbell Town in the Tasmanian Midlands. He was one of two local people permitted, between 1888 and 1902, to verify thylacine kills and to issue certificates against which reward payments were made by the Government. Without a verified and authorised claim form signed by a council warden or stipendiary magistrate, payments could not be made. It is very tempting to conclude that this thylacine was the victim of a bounty kill simply because Dr Tofft, an authorised warden, was the donor. When the bounty was first introduced, a condition of receiving a payment stipulated that the bodies had to be destroyed to prevent a second claim being made. This understandably annoyed museum director Alexander Morton who feared losing valuable specimens. After contacting the Minister for Lands and offering that the museum should be able to pay for the reward, the Minister for Lands approved the request and sent a memo outlining the new arrangement to all municipal councils (Braddon 1888).

In 1901 (the year before Tofft's donation) Alexander Morton had been sent a thylacine by Ross Council Clerk, Mr HA Percy, only a short distance south of Campbell Town. Upon its receipt, Morton discovered that young thylacines had been removed from the pouch and discarded, he wrote to inform Percy that young should be kept in the pouch 'no matter how small' (Morton 31 May 1901).

In a list of thylacine bounty claims compiled by University of Tasmania zoologist Dr Eric Guiler, there is no record of an adult thylacine with two young being presented at Campbell Town in July 1902 (Guiler 1958). Nor has such a claim been identified by historian Dr Nic Haygarth who has been updating bounty claim records and has identified a claim that can be attributed to this animal. A bounty payment was made for an adult and two juveniles to WJ Freeman of Benham, Avoca. Freeman lodged this application on 2 August 1902, and payment was made on 9 August 1902 (N Haygarth, pers. comm. 13 April 2025).

Benham was a large farming estate near Avoca. The estate workers were accommodated in a large house on the property called 'Harrymount'. When Freeman died, his funeral notice records that he had worked on the Benham estate as a young man, before becoming the estate carriage driver (*The Mercury*, 28 July 1938, p. 11).

Guiler (1958) also lists the same claim with the same dates by WJ Freeman but gives the location as 'Antill Ponds'. Both claims were for one adult and two young, and both were paid on 2 August 1902. It can be safely assumed that both records are of the same events and that the Benham record is correct.

Tofft appears to have acquired the thylacine around this time, and forwarded it and the pouch young to the museum. Morton registered the pouch young, but without knowing an exact capture date, or of Freeman's claim of 2 August, could only guess they were from a July capture and thus this vague date was recorded in the register.

A discrepancy between capture and claim dates is not uncommon in the known bounty records. To make a claim, the claimant needed a form signed by a magistrate or warden

and a signed statement verifying that the specimen had been destroyed (a task that was usually done by a council worker) (RN Paddle, pers. comm. May 2025). Paddle (2000) cites the example of a bounty claim by R Marshall who killed a thylacine on 4 February 1888, but his claim was not approved until 8 September 1888 (Paddle 2000, p. 166), probably due to administration problems as the bounty was only newly established at this time. Likewise, a kill dated as 28 November 1898 was not paid until 15 February the following year (Guiler 1958).

WJ Freeman's bounty claim was lodged on 2 August 1902 at Avoca, only 25 km from Campbell Town and within the district of Tofft's medical practice. The delay in recording the kill in Guiler's bounty data for July 1902 is most likely explained by Tofft awaiting notification from the museum that they had received the thylacine, and therefore the specimen could not be submitted for a second claim. After this, certification of the kill could be confirmed on official bounty documents thus ensuring that the body (although the body had not been destroyed, and had been sent to Haswell), was no longer available to anyone who might be tempted to claim a second bounty. To date, records of any correspondence between Morton and Tofft regarding specimens have not been found in the TMAG archives.

A further problem was the ruling that bounties were only to be paid for 'full grown', or 'half grown' thylacines (Braddon 1888). Paddle has discovered several instances where paying money for young in the pouch was refused and angered hopeful claimants (RN Paddle, pers. comm. 2025). Given the size and sparse fur covering on specimen A930, it is highly unlikely that it could survive outside of the mother's pouch; however, perhaps the large size of the two young influenced a decision to pay for them along with their mother.

One final error in the records is that on arrival at TMAG, the collecting location is listed as Campbell Town. This anomaly is most likely because Tofft was the municipal warden for Campbell Town (not Avoca). Tofft could only certify kills as the Campbell Town warden, therefore Morton assumed it was captured around Campbell Town.

There are still many questions regarding the proposition that this was a bounty animal that remain unanswered.

- Was Tofft already aware of Morton's desire for thylacines to be sent to the museum?
- Did Tofft know that pouch young should be left in place for museum specimens, even though bounty payments were not supposed to be paid for juvenile animals?
- Did Tofft delay signing the bounty claim until he knew the thylacine was accepted by the museum, and saw museum donation as part of the requirement to dispose of its body as per Government regulation?

SUMMARY AND AFTERLIVES

All five museum specimens (taxidermic mount, skeleton, pouch young, dissected organs and microscope slides) were derived from a single thylacine with young captured and killed in 1902 and subsequently shared between researchers and institutions at a time when thylacine specimens were hard to obtain. Apart from the female pouch young that was registered into the TMAG collection but later dissected for research, all have survived to the present day. They were acquired by their respective museums 34 years before the accepted extinction date of 1936, but the specimens still survive more than 123 years after being collected.

The author's detailed knowledge of the history and contents of the TMAG thylacine collection and the discovery, for the first time, of a link between Dr Tofft and Professor Haswell in the TMAG TM2 Register provided the first clue and led to the specimens being linked to a single collecting event. Each individual thylacine specimen described in this paper has been known for many years, and some have been the subject of research. However, due to a lack of a verified provenance, it was not known that these five specimens only represent a single capture and kill event.

All natural history museum specimens and their data are available for professional research. Currently research into recently extinct species is helping form a deeper understanding of the processes that led to extinction. And hopefully this will help in the prevention of others. This is increasingly important as humans grapple with the rapidly growing number of extinctions across the world, the ramifications of increasing human populations and global climate change. Without a full understanding of extinction processes, and their consequences, strategies to prevent further extinctions are difficult to accurately determine and implement.

There is no doubt that the thylacine is a hugely important icon of anthropogenic extinction. The study of specimens and their data held in museum collections, especially specimens with reliable provenances, can go a long way to assist conservation scientists to understand the ramification of a species' ecological role in the past and the effect of its absence on current species assemblages. For raw data to reconstruct population estimates and changes in historical species distribution, museum specimens are a huge source that is only just beginning to be tapped. Many historical specimens still lack any useful provenance data (apart from an identification) and their suitability as specimens to determine the effects that population decline may have had on a species may therefore be compromised.

This small project provides an example of the patient and persistent methodology required to accurately determine provenance for historical museum specimens. It involves a lot of work and time and sometimes is not possible due to a lack of written records exacerbated by changes in collection management and registration systems over many

years. However, for specimens where the data is being used to analyse extinction processes and timing, the value of datasets and their usefulness in contemporary research is increasing, thereby enhancing the veracity of the results.

In contrast to other known photographs of dead thylacines, these three images do not celebrate the animal's death or turn it into a hunter's trophy. They simply record the features of a dead animal about to be dealt with by a museum taxidermist whose task it was to re-create a life-like depiction for the public, and thus ensuring the story of this human-induced extinction remains relevant into the future.

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Tammy Gordon (past Collections Officer, Queen Victoria Museum and Art Gallery) discussed this work with me on numerous occasions, read drafts and shared her knowledge of thylacines, and the preparation of museum specimens to assist me with many issues. Patricia Eagan, previously Archivist at the Australian Museum in Sydney, alerted me to the presence of the photographs and assisted me in determining aspects of their history. Dr Sandy Ingleby (Australian Museum, Mammals Collection Manager) confirmed the images were of Haswell's thylacine and forwarded information on the specimen. Vanessa Finney (Australian Museum, Archivist) ensured that I was given access to the photographs and related documents held at the Australian Museum. She also provided valuable insights into the role of photography at the Australian Museum. Jo Huxley (Research Officer, Documents Collection, TMAG) assisted me tracing archival material, provided access to documents held in the TMAG archives and helped me to confirm dates. Fiona Möhrle, (Research Coordinator, Berlin's Australian Archive, Universität Potsdam) very kindly provided copies of her photographs of the Berlin specimens for use in this research. Jacqui Ward (Digital Collections, TMAG) assisted with sourcing and the provision of photographs for this work. Dr Bob Paddle discussed some of the themes in this paper especially during the early days of the research and provided many valuable comments on a very early draft manuscript. Historian Dr Nic Haygarth shared his knowledge of the Tasmanian Government Bounty records and discussed with me the process for claiming a bounty payment. Dr Stephen Sleightholme assisted with information on the numbers of thylacine specimens in museums and provided estimates of the number with provenance.

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(accepted 15 August 2025)

THE INSECT FAUNA OF BEN LOMOND, TASMANIA, AUSTRALIA: FINDINGS FROM AN INTENSIVE SURVEY, SUMMER 2021–2022

by Simon J Grove and Catherine J Byrne

(with two figures, one table, ten plates and one appendix)

Grove, SJ & Byrne, CJ (2025). The insect fauna of Ben Lomond, Tasmania, Australia: findings from an intensive survey, summer 2021–2022. *Papers and Proceedings of the Royal Society of Tasmania* 159: 69-84. ISSN 0080-4703. Tasmanian Museum and Art Gallery, GPO Box 1164, Hobart, Tasmania 7001, Australia (SJG*, CJB). *Author for correspondence. Email: simon.grove@tmag.tas.gov.au

An invertebrate fauna survey of Ben Lomond, in the Northeast Highlands of Tasmania, was conducted over the period November 2021 to February 2022 as part of the Tasmanian Museum and Art Gallery's *Expeditions of Discovery* program. The survey focused on insects in the higher-elevation parts of the mountain massif, taking in the sub-montane, montane and alpine zones. We identified numerous species that are noteworthy for their apparent rarity or biogeographical interest, including many that are endemic to higher-elevation parts of Tasmania. The Tasmanian Midlands, comprising lower-elevation, low-rainfall environments, have long been considered the source of a substantial discontinuity dividing Tasmania's higher-elevation flora and fauna to the east and west, with the Northeast Highlands being considered depauperate relative to the higher-elevation parts of western Tasmania. Our survey recorded many species known previously from western Tasmania but not documented from east of the Midlands, including some 30 moth species. In doing so, it has greatly reduced this perceived east–west differential regarding Tasmania's sub-montane to alpine insect fauna.

Key Words: insect biodiversity, Ben Lomond, Tasmania.

INTRODUCTION

The Tasmanian Museum and Art Gallery (TMAG) instituted an *Expeditions of Discovery* program in 2017. The program entails an expedition annually, conducted by TMAG Zoology and Herbarium staff. The zoological focus is typically on insects. We have previously reported in this journal, and elsewhere, on the findings from earlier expeditions (Baker *et al.* 2020, Baker *et al.* 2021a, b, Grove *et al.* 2021, 2022). Our entomological survey of Ben Lomond, in northern Tasmania (fig. 1), was conducted over the period November 2021 to February 2022.

METHODS

All sampling localities lay within the relatively accessible northern half of Ben Lomond National Park (fig. 2). Geologically, the entire area comprises a dolerite massif, albeit with one outcrop of Triassic sedimentary rocks at Coalmine Crag. Further details regarding the plateau's geology, geomorphology, soils and vegetation communities are provided in Davies and Davies (1989).

The survey focused on the fauna of the Ben Lomond Plateau, a zone lying mostly above 1,400 m elevation, where the environment can be described as 'alpine'. This zone (pl. 1) comprises the main high-elevation plateau of Ben Lomond, along with its incised, shallow valleys. Ben Lomond lacks any truly alpine species of *Eucalyptus*, in marked contrast to the western mountains and Central Plateau; it also lacks the cold-adapted taller conifers of the west. The entire plateau, therefore, sits above the treeline, and the vegetation comprises alpine shrublands and grasslands on free-draining ground, with bogs on more poorly drained ground. Exposed areas feature lichen heath, or feldmark. Boulder-fields and talus slopes are also prominent features.

To a lesser extent, sampling was also conducted on the northern ramparts of the plateau in the vicinity of Jacobs Ladder and Carr Villa, at around 1,200 m elevation – a zone which we characterise as 'montane'. Here, alpine cider gum *E. archeri* woodland predominates, grading to stunted gum-topped stringybark *E. tasmaniensis* (formerly known as *E. delegatensis* subsp. *tasmaniensis*) at lower elevations. In fire-protected situations there are patches of rainforest, dominated by myrtle beech *Nothofagus cunninghamii*, while shrublands predominate on dolerite boulder-fields and towards the upper elevational limit of the zone (broadly, the top of the mountain's dolerite 'ramparts'). Similar vegetation occurs on the higher slopes of other mountains in northeast Tasmania and on the Central Plateau.

Some additional sampling was conducted in the vicinity of the campground along the Ben Lomond Road, at around 1,000 m elevation, which we characterise as 'submontane'. This zone comprises a broad, continuous belt of forest around the entire Ben Lomond massif. Typically, it is dominated by tall *E. delegatensis* subsp. *tasmaniensis* with a shrubby understorey. Similar forest is widespread at intermediate elevations throughout Tasmania.

The main expedition was held from 6–12 February 2022. Prior to this, two preliminary visits were made. An initial reconnaissance visit (by SJG & Lynne Forster) took

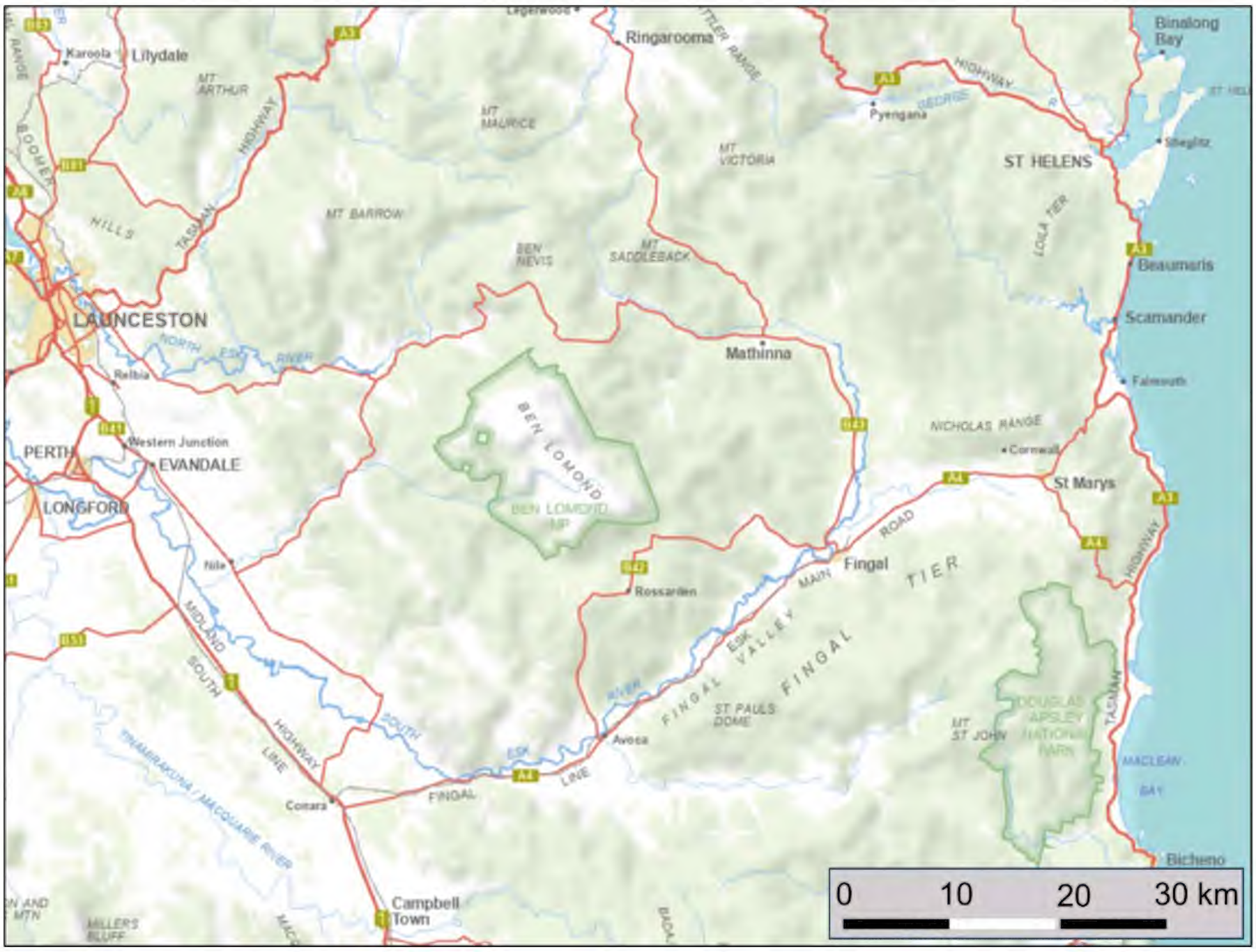

FIG. 1 — Part of northeastern Tasmania, showing the location of Ben Lomond National Park.

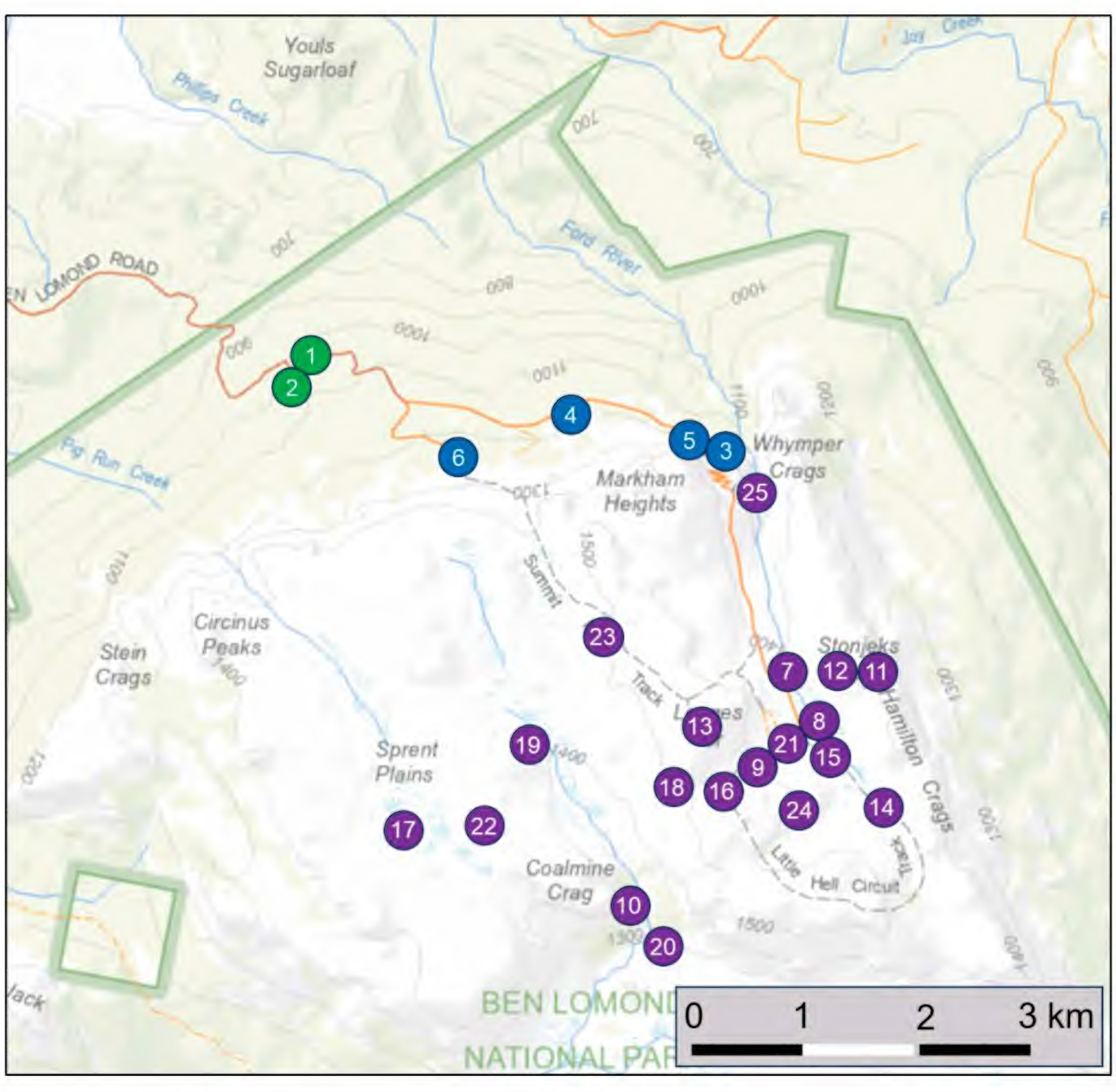

FIG. 2 — The northeastern portion of Ben Lomond National Park, showing the approximate locations of the collecting localities, numbered as in table 1. ‘Sub-montane’ localities are green; ‘montane’ are blue; and ‘alpine’ are purple.

PLATE 1 — Alpine shrubland on the northern part of the Ben Lomond plateau. Photo: Simon Grove

PLATE 2 — One of four Malaise traps used to sample flying insects. This one was in montane shrubby woodland near Carr Villa. Photo: Simon Grove

place from 5–6 December 2021. During this visit, some opportunistic hand collection of terrestrial insects in the vicinity of the campground was undertaken. Malaise traps – tent-like flight intercept traps (pl. 2) – were established at three locations at this time: a 'submontane' location near the Ben Lomond Road campground, a 'montane' location at Carr Villa, and an 'alpine' location in Meadow Vale. These sampled continuously, with a service and bottle changeover (by SJG) on 11 January 2022, until their removal during the main expedition, between 8–11 February 2022 (by SJG & Lynne Forster). A fourth 'alpine' Malaise trap was erected on the saddle near Normans Folly for the duration of the main expedition. Light traps – both UV lights (*LepiLed*: Brehm 2017) and bucket traps – were set up for single evenings or nights during the main expedition at a range of locations spanning the montane–alpine continuum, as detailed below. In addition, a 'submontane' UV light was operated (by SJG) near the Ben Lomond Road campground for the single night of the December 2021 reconnaissance visit. Arrays of ten dry pitfall traps (plastic pots) and eight pan traps (plastic picnic bowls – two yellow, two white, two green and two blue, charged with water and detergent) were also set up for the duration of the main expedition at two 'alpine' locations: close to the ski village, and close to the start of the Meadow Vale circuit. Elsewhere, sampling was by means of a combination of sweep-netting, vegetation beating, dip-netting and other forms of hand collection (referred to below, in aggregate, as netting/hand collection). All insect-collecting operated under DPIPWE Permit Number FA21002.

Table 1 lists the main localities visited grouped by elevational zone. Their locations are also plotted on figure 2.

Collected specimens were registered into the collections of the TMAG, Hobart. Data pertaining to these specimen records were provided to the *Atlas of Living Australia* (ALA) and the Tasmanian *Natural Values Atlas* (NVA). Malaise trap residues, containing thousands of further specimens belonging to taxa beyond the expertise of the authors, are also stored at the TMAG and remain available for further taxonomic sorting and research.

The ranges of described Tasmanian and Australian invertebrates are often poorly documented, presenting challenges for identifying which records represent significant range extensions/infills. Unless otherwise stated, we use the presence or absence of records on the ALA, which aggregates museum and other institutional collections and observational data from across the nation (and beyond), as our benchmark as to where a given species is already 'known' to occur'. However, we use this approach with caution since few museum or institutional collections are fully digitised, and the validity of observational (non-specimen-based) records is often questionable. It is worth noting that taxa that we were unable to identify to species level, either because we lack the relevant expertise or because they are apparently undescribed, cannot even be assessed in this regard.

RESULTS

In total, 530 insect taxa were identified from our surveys (appendix 1). A sizeable proportion of these (187 taxa: 35%) remain unidentified at the species level. Best identified are the members of 'minor' orders, in which all taxa where we attempted identifications were identified to species. Moths and beetles were also comparatively well identified, while flies, bugs and wasps were less so – indicative of the poorer knowledge base in Australia generally regarding these faunal elements. Many of our records apparently represent significant range extensions, chiefly of alpine or montane species known from the mountains west of the Midlands and not previously recorded from the northeast.

Alpine

This zone produced the greatest number of species of interest – most likely because more of our sampling was focused in this zone, in combination with the sheer extent of ground that this zone occupies on Ben Lomond and the fact that, compared to similar environments in western Tasmania, it appears to have been poorly sampled in the past.

TABLE 1 — Main localities visited, and the collecting techniques employed. The given coordinates are approximate and usually represent the central point of wider collecting areas

Number on map	Locality	Coordinates	Techniques
Submontane zone			
1	Ben Lomond Road: campground environs	41.5024°S, 147.6131°E	UV light trap, netting/hand collection, spotlighting
2	Ben Lomond Road campground: 150 m to SW	41.5035°S, 147.6126°E	Malaise trap
Montane zone			
3	Ben Lomond Road: base of Jacobs Ladder	41.5105°S, 147.6579°E	Sweep net, hand collection, UV light trap
4	Ben Lomond Road: roadside between Jacobs Ladder and lower car park	41.507°S, 147.649°E	Netting/hand collection
5	Ben Lomond Road: foot of Jacobs Ladder	41.5087°S, 147.6381°E	Bucket light trap
6	Carr Villa environs	41.511°S, 147.629°E	Malaise trap, UV light trap, bucket light trap, netting/hand collection
Alpine zone			
7	Ben Lomond Road: roadside NE of ski village	41.5292°S, 147.6668°E	Netting/hand collection
8	Ben Lomond Road: roadside close to ski village	41.5348°S, 147.6649°E	Bucket light trap
9	Big Ben Creek environs	41.536°S, 147.661°E	Netting/hand collection
10	Coalmine Crag environs	41.543°S, 147.644°E	Netting/hand collection
11	Hamilton Crags: Stonjeks Lookout	41.5291°S, 147.6779°E	Netting/hand collection
12	Hamilton Crags: W slopes	41.528°S, 147.674°E	Netting/hand collection
13	Legges Tor and Giblin Peak summit area	41.532°S, 147.659°E	Netting/hand collection
14	Meadow Vale: Little Hell Circuit Track	41.5347°S, 147.6702°E	Malaise trap, UV light trap, bucket light trap, netting/hand collection, dip-net
15	Meadow Vale: start of Little Hell Circuit Track	41.5335°S, 147.6689°E	Pan traps, pitfall traps, UV light trap, bucket light trap
16	Meadow Vale: Little Hell Circuit Track: Chairlift shed	41.5353°S, 147.6617°E	UV light trap
17	Menamatta Tarns area	41.5409°S, 147.6289°E	Netting/hand collection, dip-net
18	Normans Folly: saddle nearby	41.5375°S, 147.6584°E	Malaise trap, bucket light trap
19	Rafferty Creek: upper valley	41.537°S, 147.643°E	Netting/hand collection, dip-net
20	Rafferty Creek: valley SE of Coalmine Crag	41.552°S, 147.653°E	Netting/hand collection
21	Ski Village environs	41.5299°S, 147.6699°E	Pan traps, pitfall traps, UV light trap, bucket light trap, netting/hand collection, spotlighting
22	Sprent Plains E of Menamatta Tarns	41.539°S, 147.633°E	Netting/hand collection
23	Summit Pass Track above Carr Villa	41.528°S, 147.652°E	Netting/hand collection
24	Surprise Vale: plateau and ledges to N	41.539°S, 147.669°E	Netting/hand collection
25	Watchtower lookout environs	41.5136°S, 147.6614°E	Netting/hand collection

The Tasmanian endemic jewel-beetle *Castiarina macquillani* (Buprestidae) (pl. 3) is one of the key finds. A single specimen was captured in flight, north of Surprise Vale. Prior to our expedition, it was only known from a series of specimens collected in 1987 on Algonkian Mountain, west of the Franklin River valley in western Tasmania, though it has since been reported from elsewhere in the west (Mount Doris and near Cradle Mountain) as well as near Liawenee on the Central Plateau. Two further jewel-beetle species were also collected, although they are not new for Ben Lomond: the Tasmanian endemic *Castiarina rudis*, a high-elevation species associated with *Orites* shrubs which is otherwise known from a scattering of localities on the Central Plateau and Vale of Belvoir, though it has since also been reported from Mount Barrow to the north of Ben Lomond; and *Nascioides quadrinotatus*, a lower-elevation species whose larvae feed in the wood of *Nothofagus cunninghamii*. The single specimen of the latter species was caught in a Malaise trap in Meadow Vale, far from the nearest *N. cunninghamii* tree. It presumably originated from rainforest around the periphery of the massif.

Another key beetle find was the Tasmanian endemic leaf-beetle *Palaeomela cribricollis* (Chrysomelidae) (pl. 4). Our single specimen was found close to the ski village, where the most-recent previous specimen was also collected in 1999. Otherwise, the species is only known from the type specimen, collected on Kunanyi–Mount Wellington about a century previously. Sadly, our record does little to improve understanding of the species' biology, since it was found on a small rock alongside a path while SJG and Lynne Forster were spotlighting at night. Despite intensive searching on likely foodplants for the duration of our expedition, no further specimens came to light.

The ground-beetle *Scopodes donabaueri* (Carabidae), apparently endemic to the Ben Lomond Plateau, was found widely during our expedition, typically under stones in feldmark-type settings. Four apparently undescribed (and probably Tasmanian endemic) beetle species recorded during our survey are the weevils *Exithius* sp TMAG_F122864 and Leptopiini gen. nr *Enchymus* sp. TMAG_F122746 (Curculionidae), for which our records are the only ones known; the weevil *Merimnetes* ZIMMERMAN sp. nov. (Curculionidae), which is also known from some other Tasmanian mountains; and the darkling-beetle *Adelium* sp. TMAG_F122419, which is also known from Quamby Bluff. The *Enchymus* relative, which was also found in the montane zone, is of note as it may be a close relative of the 'Weldborough Forest weevil', a very similar (and also undescribed) taxon that is on the Tasmanian Threatened Species list and is known only from the Poimena area, further to the east.

Finds of several other beetle species, all of which are endemic to Tasmania, appear to represent the first known records for northeast Tasmania of species otherwise known from west of the Midlands, as follows: the ground-beetle *Stichonotus decoloratus* (Carabidae); the ladybird *Diomus flavolaterus* (Coccinellidae); and the marsh-beetles *Copiacyphon uncatus*, *C. variabilis* and *Nothocyphon lanceolatus* (Scirtidae). A further marsh-beetle species,

PLATE 3 — The jewel beetle *Castiarina macquillani* (Buprestidae), photographed on the northern Ben Lomond plateau. Body length 16 mm. Photo: Simon Grove

PLATE 4 — The leaf-beetle *Palaeomela cribricollis* (Chrysomelidae), found on Ben Lomond two decades since last observed; otherwise known only from a single specimen collected over a hundred years ago on Kunanyi–Mount Wellington. Body length 5 mm. Photo: Simon Grove

Pictacara montana, whilst common in the west, was seemingly last recorded in the northeast (on Ben Lomond) in 1965.

The alpine-zone moth fauna from this survey includes many rarities and 22 new records for the northeast. Greatest diversity prevailed in Geometridae, with 25 species collected in the alpine zone. Most are members of the amphipolar tribe Xanthorhoini (sub-family Larentiinae), which has diversified widely in montane areas, particularly in Tasmania. Member species are usually diurnal, and often colourful. *Chrysolarentia* is the largest Australian genus in this tribe, with nine of the 33 described Tasmanian-occurring species collected during this expedition from

PLATE 5 — The moth *Microdes oriochares* (Geometridae), newly recorded for northeast Tasmania on Ben Lomond. Wingspan 20 mm. Photo: Cathy Byrne

PLATE 6 — The water snipe-fly *Dasyomma maculipenne* (Athericidae), newly recorded for northeast Tasmania on Ben Lomond. Body length 6 mm. Photo: Simon Grove

either the alpine or montane zones. For example, the endemic *Chrysolarentia photographica* was collected from Little Hell Circuit, representing a new record for the northeast – the only other known specimens having been found in the Tasmanian Central Highlands (Bush Blitz 2016) and on Mount Louisa in the Southwest National Park (Bush Blitz 2017), though there are observational records on the ALA from the 1990s, from both the southwest and the Central Highlands. From the same genus, a single specimen of *C. subrectaria*, taken at night (by light) in the ski village, is the first record for this species in Tasmania on the ALA, though it is widespread in the southeastern part of the Australian mainland. However, the holotype was collected from 'Tasmanie' (Guenée 1857) and there are further, undocumented records from the southeast of the state (P. McQuillan, pers. comm.). Four species from two other xanthorhoine genera, *Epyaxa* and *Xanthorhoe,* were also collected, with all but one of these confined to the alpine and montane zones.

Three more larentiine species of note from this survey are from other tribes. Most notable is *Microdes oriochares* (Larentiinae: Eupitheciini) (pl. 5), eight specimens of which were collected from the alpine zone, with four from the montane and one from the submontane zone. These are the first known Tasmanian records of this species, which also occurs at high elevations in Victoria, and on Mount Kosciuszko (NSW). In the same genus, a single specimen of the Tasmanian endemic *M. leptobrya* was collected at light near the ski village. The few recent, specimen-based records for this species are from high elevations in southwestern Tasmania (Bush Blitz 2017) and the Vale of Belvoir (Bush Blitz 2011). Otherwise, Turner (1939) described three type specimens from Waratah. Larvae of *Microdes* species typically feed on flower parts. Two specimens of *Poecilasthena panapala* (Larentiinae: Asthenini) were collected on the Plateau; in Tasmania, this moth is otherwise known from three 1934 specimens from Cradle Mountain; it is also present in Victoria's Central Highlands. Larval foodplants are unknown, but other species in the same genus feed on Epacridaceae.

A few species from other moth families collected in the alpine zone are also considered to be rare. The tribe Archipini (Tortricidae: Tortricinae) has diversified widely in alpine environments in Tasmania (McQuillan 1992). During our survey, six such species were collected. A single specimen of *Technitis technica*, collected at a light trap set in the ski village, represents a new record for the northeast. Whilst the ALA references two recent observational records from Burnie, specimen-based records are otherwise only known (in the Tasmanian part of its range) from Waratah (1939), Deloraine (1963) and Mount King William I (Central Highlands) (McQuillan 1992). The last of these records references a larva found and reared on the shrub *Ozothamnus thyrsoideus*, which is absent from the Ben Lomond Plateau; however, *O. rodwayi* is present and could be an alternative larval foodplant. *Acropolitis* sp. ANIC 6 is an as-yet undescribed and apparently rare archipine tortricid moth, a single specimen of which was collected in the ski village. Another Tasmanian endemic moth, *Thermeola tasmanica* (Erebidae: Arctiinae: Lithosiini), was collected in both the alpine and montane zones. All previous specimen records are from the south of the state, including Mount Field, Kunanyi–Mount Wellington, the Hobart area and, most recently, the Southwest National Park (Bush Blitz 2017); the only observational record (on the ALA) is also from the south (Nicholls Rivulet). Lithosiine caterpillars feed on lichens and algae.

Amongst the true flies, as with the beetles and moths, several of our finds represent the first records for the northeast of Tasmania of species otherwise known from west of the Midlands, as follows: the Tasmanian endemic water snipe-fly *Dasyomma maculipenne* (Athericidae) (pl. 6), whose larvae live in cold, shallow streams; the endemic austral snipe-fly *Austroleptis multimaculata* (Austroleptidae)

PLATE 7 — The austral snipe-fly *Austroleptis multimaculata* (Austroleptidae), newly recorded for northeast Tasmania on Ben Lomond. Body length 3 mm. Photo: Simon Grove

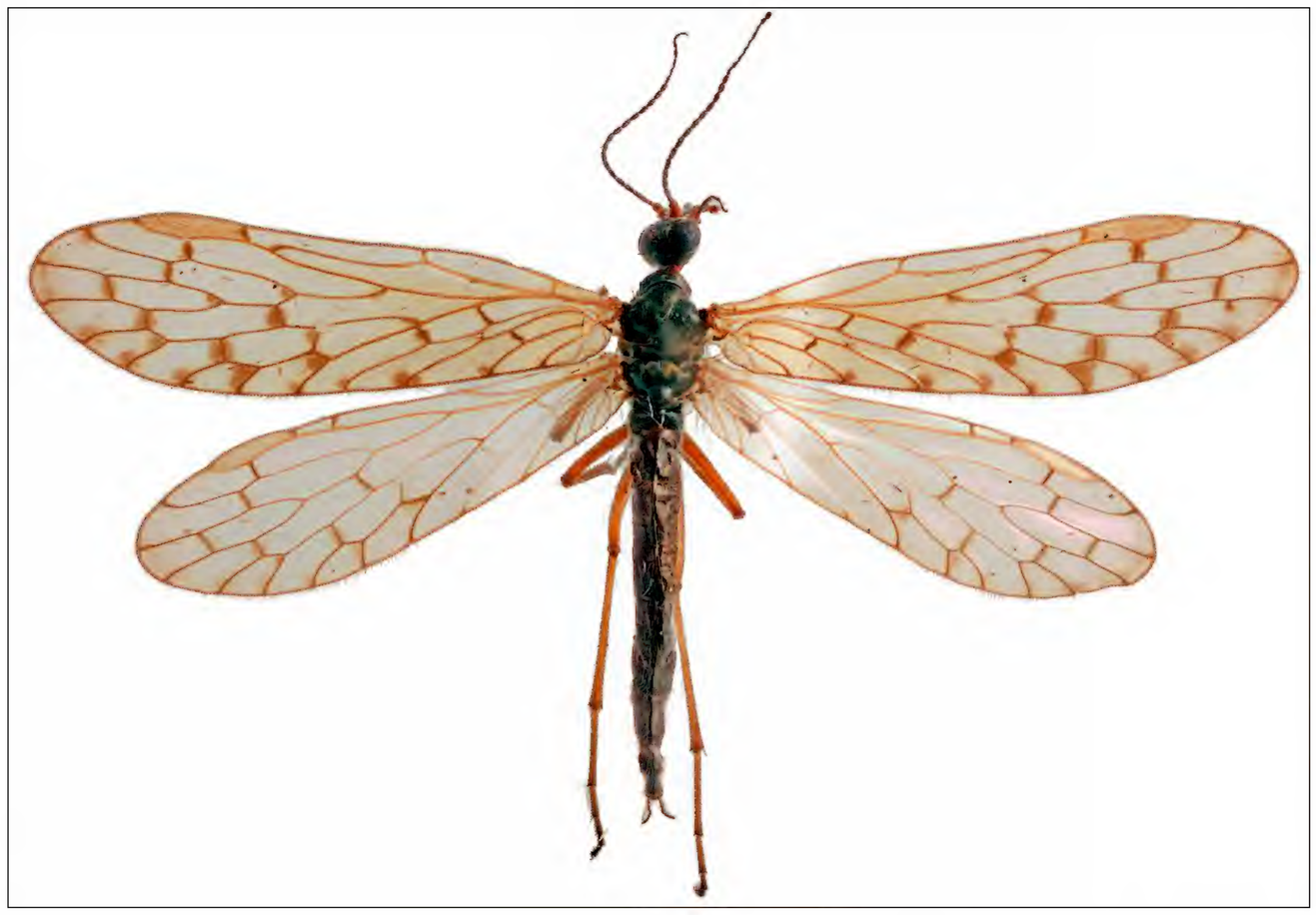

PLATE 8 — The scorpion-fly *Nannochorista maculipennis* (Nannochoristidae), newly recorded for northeast Tasmania on Ben Lomond. Body length 7 mm. Photo: Simon Grove

(pl. 7); the snipe-fly *Chrysopilus bifasciatus* (Rhagionidae); the endemic axe-snouted fly *Pelecorhynchus albolineatus* (Pelecorhynchidae); the endemic cranefly *Ischnotoma rubroabdominalis* (Tipulidae); the endemic dagger-fly *Empis maculosa* (Empididae); the shore-fly *Nostima duoseta* (Ephydridae); the ant-associated hoverfly *Oligeriops chalybeus* (Syrphidae), which in Tasmania is otherwise only known from the Vale of Belvoir; and the picture-winged fly *Spathulina acroleuca*, which is common on the Australian mainland but in Tasmania is only otherwise known from a 1965 record from Waratah. Our record of the bone-skipper fly *Piophilosoma norrisi* (Piophilidae), which was swept from a roadside wallaby carcase, comprises only the second of its species on the ALA (the first is an observation from 2020 near Fingal, also in the northeast of Tasmania).

Amongst the true bugs, a similar pattern emerges, in which our finds represent the first records for the northeast of Tasmania, as follows: the Tasmanian endemic shield-bug *Eupolemus picturatus* (Acanthosomatidae); the artheneid bug *Dilompus woodwardi* (Artheneidae); the seed-bugs *Remaudiereana inornata*, *Udeocoris nigroaeneus* and *Euander torquatus* (Rhyparochromidae); the Tasmanian endemic cicada *Diemeniana hirsuta* (Cicadidae); and the leafhopper *Arawa novella* (Cicadellidae).

Representatives of other insect orders showing this same pattern are as follows: the rainbow-ant *Iridomyrmex alpinus* (Formicidae); the ichneumonid wasp *Labium montivagum* (Ichneumonidae); the Tasmanian endemic scorpion-fly *Nannochorista maculipennis* (Nannochoristidae) (pl. 8); the endemic earwig *Gonolabis tasmanica* (Anisolabididae) (pl. 9) and the endemic caddisfly *Plectrotarsus tasmanicus* (Plectrotarsidae). Our record of the endemic giant stonefly

PLATE 9 — The earwig *Gonolabis tasmanica*, newly recorded for northeast Tasmania on Ben Lomond. Body length 25 mm. Photo: Simon Grove

Eusthenia spectabilis appears to be the first for Ben Lomond, although in the northeast it is otherwise known from the Mount Arthur area. Additionally, we recorded two Tasmanian endemic mountain-dwelling grasshoppers, *Russalpia albertisi* and *Tasmanalpina clavata* (Acrididae), both of which have previously been recorded from Ben Lomond.

Montane

An apparently undescribed (and probably Tasmanian endemic) weevil species recorded during our survey is code-named Leptopiini gen. nr *Uroleptops* sp. TMAG_F139310 (Curculionidae), for which our single Ben Lomond specimen is the only one known. The same applies to our single Ben Lomond specimen of the helosciomyzid fly code-named *Eurotocus* sp. TMAG_F122966 (Helosciomyzidae).

As with the alpine zone, the insect fauna here included species for which our specimens represent the first for the northeast of Tasmania. Most such species seem to be generally associated with higher elevations and/or wetter forests. Among the beetles, these include the Tasmanian endemic soft-winged flower-beetle *Hypattalus montanus* (Melyridae); the Tasmanian endemic mycterid beetle *Trichosalpingus fumatus* (Mycteridae); and the ulodid beetle *Meryx aequalis* (Ulodidae). Amongst the true flies, these include the cranefly *Acracantha sydneyensis* (Tipulidae), the soldierfly *Australoactina costata* (Stratiomyidae) and the stiletto-flies *Actinomeros corniculaticaudatus* (a Tasmanian endemic), *Anabarhynchus montanus*, and *A. whitei* (also endemic) (all Therevidae). Amongst the true bugs, they include the leafhopper *Rhotidoides montana* (Cicadellidae) and the Tasmanian endemic cixiid planthopper *Aka dobsonensis* (Cixiidae) (pl. 10). The crabronid wasp *Acanthostethus tasmanicus* (Crabronidae) is also apparently new for the northeast, though it is known from the southeast.

PLATE 10 — The plant-bug *Aka dobsonensis* (Cixiidae), newly recorded for northeast Tasmania on Ben Lomond. Body length 4 mm. Photo: Simon Grove

Some 30 moth species recorded in the montane zone represent new records for the northeast, with 11 of these also collected in the alpine zone. These records highlight a regional knowledge gap that seems remarkable given that many of the species involved are common, large and distinctive, which ought to render them both readily collectable and identifiable. Larentiine moths (Geometridae: Larentiinae) collected in this zone include *Chrysolarentia heteroleuca* (Xanthorhoini) representing the only known Tasmanian record other than a 2024 observation on the ALA from Golden Valley (north of the Central Plateau); the species is relatively common in Victoria and NSW. A specimen of *C. leucozona*, collected at Carr Villa, represents only the second known Tasmanian specimen, the other being a 1909 record on the ALA from St Patricks River, about 20 km north of Ben Lomond; the species is also found in Victoria. A specimen of *Horisme mortuata* (Eupitheciini) collected at Carr Villa is one of two Tasmanian records for this species, the other (on the ALA) an observational record from the south of the state (Risdon Vale); the species also occurs in Victoria and NSW. *Melitulias oriadelpha* (Hydriomenini) was collected at multiple localities in the submontane zone, including Carr Villa. In Tasmania the species is otherwise known from the type locality, Cradle Mountain (Turner 1926) and from the far northwest; the species also occurs in Victoria and NSW.

Two notable erebid moth species in the lichen- and alga-feeding tribe Lithosiini (Erebidae: Arctiinae) were collected. A major discovery at Carr Villa concerns *Halone sobria*, a species with no other ALA records; however, there exists one 1980 specimen, from Mount Nelson, Hobart, in the Australian National Insect Collection (ANIC). Anecdotally, it appears that the species also occurs on Kunanyi–Mount Wellington (P. McQuillan, pers. comm.). The species is probably endemic to Tasmania. The syntype, described under the name *H. nephobola* (Turner 1944) (now synonymised), was collected in Hobart; but the original type locality of *H. sobria* (Walker 1854) was given, seemingly in error, as Port Natal (South Africa). Also collected from Carr Villa was *Philenora omophanes*. The two other known Tasmanian specimen records (ANIC) are from Derwent Bridge (1989) and Beaconsfield (2004); there is also a 2021 ALA observational record from Loongana. The species also occurs in Victoria and on Mount Kosciusko (NSW).

Regarding Australia's largest moth family (Oecophoridae), a notable find was a specimen of *Thema endesma* (Oecophorinae: *Chezala* Group), collected at Jacobs Ladder. The species is otherwise represented in Tasmania by 1934 specimens in the TMAG collection from Kunanyi–Mount Wellington and Burnie; there is also a 2021 observational record (ALA) from Kunanyi–Mount Wellington. This species also occurs in Victoria and the ACT. It belongs to a very large guild of oecophorid moths whose larvae feed among leaf litter on dead leaves, particularly those of eucalypts. A single specimen of *Scieropepla serina* (Xyloryctidae) was collected. The family is endemic to Australia. The few records on the ALA for this species include a 1929 specimen from Scottsdale and several recent observational records recorded from the south (Sandford and Nicholls Rivulet) and northwest (Loongana) of the state. The larvae typically feed on dead eucalypt leaves still connected to fallen branches.

Other insect species of note in the montane zone are the following: the idiostolid bug *Monteithocoris hirsutus*,

which has long been considered endemic to the rainforests of northeast Tasmania, although recently also found on Tasman Island in the southeast; spotted mountain-grasshopper *Monistria concinna*; and the mountain katydid *Acripeza reticulata*. The latter two species were already known from Ben Lomond.

The montane zone is where most of the introduced species were collected, though most were present in the other zones as well. The list of exotic taxa comprises the following species: gorse seed-weevil *Exapion ulicis*, a species which in Tasmania seems to occur far more widely than its chief host-plant, *Ulex europaeus*; red dung-beetle *Aphodius fimetarius*; striped dung-fly *Oxysarcodexia varia*; European bumblebee *Bombus terrestris audax*; European wasp *Vespula germanica*; and cabbage white butterfly *Pieris rapae* and diamondback moth *Plutella xylostella* (both collected from the alpine zone only). European honeybees *Apis mellifera* were common throughout the survey area but were not collected.

Submontane

The insect fauna at the localities sampled were typical of the habitat, albeit with some taxa of particular note. Trap samples were rich in 'lowland' species that were absent from samples collected at higher elevations. One of the rarer finds was the Tasmanian endemic false darkling-beetle *Ctenoplectron agile* (Melandryidae), otherwise known from just two localities, neither of which is in the northeast. The specific identity of a picture-winged fly codenamed Tephritidae unplaced sp. TMAG_F125990 remains unclear but it represents the only member of its taxon in the TMAG collections and may be an undescribed species. The same applies to the click-beetle *Parablax* sp. TMAG_F123004 (Elateridae) and to the weevils *Decilaus* sp. TMAG_F121147 and *Poropterus* sp. TMAG_F121146 (Curculionidae) – the last taxon represented by four individuals.

Several finds of otherwise relatively common and widespread species appear to represent the first occurrences from the northeast of Tasmania. These include: the hairy fungus-beetle *Litargops intricatus* (Mycetophagidae); the Tasmanian endemic marsh-beetles *Macrodascillus insolitus* and *Perplexacara latusmandibulara* (Scirtidae); the endemic false flower-beetle *Scraptia ocularis* (Scraptiidae); the leaf-beetle *Platycolaspis pubescens* (Chrysomelidae); the heteromyzid fly *Trixoleria maculata* (Heteromyzidae); the endemic snipe-fly *Atherimorpha occidens* (Rhagionidae); the endemic stiletto-fly *Anabarhynchus lanatus* (Therevidae); the soldier-flies *Damaromyia whitei* (Tasmanian endemic) and *Antissella parvidentata* (both Stratiomyidae); and the geometrid moth *Circopetes obtusata* (Geometridae). Our record of the austral snipe-fly *Austroleptis rhyphoides* (Austroleptidae) represents only the second one known from the northeast, while that of the endemic archipine tortricid moth *Rupicolana crotala* (Tortricidae) is the only one known other than the type specimens from Deloraine (Meyrick 1910).

DISCUSSION

These surveys on Ben Lomond have brought to light a distinctive insect fauna (appendix), largely comprising species adapted to the cool-to-cold and often wet conditions that prevail at higher elevations in Tasmania.

Our records of seven insect taxa may possibly be the first for their species in Tasmania, though only one, the geometrid moth *Microdes oriochares*, is a described species; the other six may well prove to be both undescribed and endemic to Tasmania. Many of our finds represent range extensions for species formerly known only from similar environments to the west of the Midlands, such as on the Central Plateau or in the mountains of western Tasmania. These new detections reduce the insect faunistic differential between the Northeast Highlands and western Tasmania, in which the drier, lower-lying Midlands have been perceived as forming a more-or-less inhospitable barrier to the dispersal of plants and animals adapted to the cooler or wetter conditions of the mountains to either side (Mesibov 1996, Smith 2024 and their references therein). Their presence on both sides of this divide raises questions as to whether the Midlands are indeed an impervious barrier, or whether today's relatively mild Interglacial climate has effectively isolated cold-adapted species at high elevations on either side of the Midlands, whereas they might once have had more continuous distributions (albeit at lower elevations) during past Glacial periods. Perhaps different explanations apply to different species, as noted by Smith (2024): those which are stronger flyers, or which are more prone to being carried across country in strong air-currents once airborne, may cross the divide occasionally, whereas those that cannot fly have present-day distributions that are refugial. The extent to which either trait will allow species to cope with ever-rising temperatures during rapid climate changes is unknown. At least the absence of alpine eucalypt species on Ben Lomond limits the prospects that alpine shrubland habitats will be subsumed into woodland – for a while, at least.

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APPENDIX

Insect fauna collected on Ben Lomond, summer 2021–2022

The elevational zone(s) in which each taxon was found: a – alpine, m – montane, s – sub-montane.
Taxa marked with + are new records for Tasmania, those marked with i are introduced taxa in Tasmania.

BLATTODEA (COCKROACHES & TERMITES)
Ectobiidae
as *Balta* unplaced
ams *Ellipsidion* sp TMAG_F13423

COLEOPTERA (BEETLES)
Anthicidae
a Anthicidae unplaced sp TMAG_F123436
Anthribidae
a Anthribinae gen nr *Cacephatus* sp TMAG_F6815
m *Xynotropis* TFIC sp 01
Attelabidae
s *Metopum* sp TMAG_F123338
Bostrichidae
s *Xylion collaris (Erichson, 1842)*
m *Xylobosca canina* (Blackburn, 1893)
Brentidae
a *Apion tasmanicum* Lea, 1910
am i *Exapion ulicis* (Forster, 1770)
Buprestidae
a *Castiarina macquillani* (Barker, 1988)
a *Castiarina rudis* Carter, 1934
a *Nascioides quadrinotatus* (Van de Poll, 1889)
Byrrhidae
a *Microchaetes scoparius* Erichson, 1842
a *Pseudomorychus mixtus* (Lea, 1907)
Cantharidae
am *Chauliognathus lugubris* (Fabricius, 1801)
ams *Chauliognathus tricolor* (Castelnau, 1840)
as *Heteromastix pauxillus* (Blackburn, 1888)
Carabidae
s *Agonocheila curtula* (Erichson, 1842)
a *Gnathaphanus melbournensis* (Castelnau, 1867)
a *Hypharpax australis* (Dejean, 1829)
am *Hypharpax peronii* (Castelnau, 1867)
a *Notagonum marginellum* (Erichson, 1842)
a *Promecoderus* sp TMAG_F116117
a *Scopodes boops* Erichson, 1842
a *Scopodes donabaueri* Baehr, 2010
s *Scopodes tasmanicus* Bates, 1878
a *Stichonotus decoloratus* Baehr, 2013
a *Trechimorphus diemenensis* (Bates, 1878)
Cerambycidae
s *Callidiopis scutellaris* (Fabricius, 1801)
a *Dorcadida bilocularis* White, 1846
s *Mecynopus cothurnatus* Erichson, 1842
s *Zoedia divisa* Pascoe, 1862
Chrysomelidae
a *Aporocera argentata* Chapuis, 1875
m *Aporocera viridipennis* (Saunders, 1842)
a *Arsipoda chrysis* (Olivier, 1808)
m *Cadmus strigillatus* Chapuis, 1875
a *Chaetocnema calida* (Blackburn, 1896)
m *Ditropidus subaeneus* Chapuis, 1875
as *Eboo viridula* (Erichson, 1842)
am *Monolepta tasmaniensis* Lea, 1923
a *Palaeomela cribricollis* (Lea, 1929)
a *Paropsis porosa* Erichson, 1842
ams *Paropsisterna bimaculata* (Olivier, 1807)
a *Paropsisterna obliterata* (Erichson, 1842)
a *Peltoschema* DE LITTLE sp 03
a *Peltoschema delicatula* (Chapuis, 1877)
am *Peltoschema orphana* (Erichson, 1842)
s *Platycolaspis pubescens* Reid, 1994
Clambidae
s *Sphaerothorax tasmani* (Blackburn, 1902)
Cleridae
am *Lemidia cicatricosa* Lea, 1907
a *Lemidia nigrovaria* Lea, 1907
ams *Lemidia subaenea* Gorham, 1877
ms *Neoscrobiger rauciceps* Blackburn, 1900
s *Parapylus bicinctus* (Newman, 1842)
s *Tenerus abbreviatus* White, 1849
s *Thriocerodes* TFIC sp 01
Coccinellidae
a *Coccinella transversalis* Fabricius, 1781
m *Diomus elutus* (Lea, 1902)
a *Diomus flavolaterus* (Lea, 1926)
s *Rhyzobius forestieri* (Mulsant, 1853)
ams *Rhyzobius josephi* Tomaszewska, 2010
s *Rhyzobius pelion* Tomaszewska, 2010
m *Rhyzobius pulcher* Blackburn, 1892
ms *Rhyzobius* sp TMAG_F123175
Corylophidae
s *Holopsis* unplaced
m *Sericoderus* TFIC sp 16
Cryptophagidae
s *Antarcticotectus tasmanicus* (Blackburn, 1907)
m *Cryptogasterus lawrencei* Leschen, 1996
m *Notocryptus* sp TMAG_F123179
Curculionidae
s *Aades cultratus* (Fabricius, 1775)
ams *Ancyttalia oleariae* (Lea, 1906)
am *Aoplocnemis* sp TMAG_F122955
m *Aoplocnemis* sp TMAG_F123143
s *Decilaus* sp TMAG_F121147
a *Elleschodes* TFIC sp 08
s *Elleschodes wellingtoniensis* (Lea, 1908)
s *Emplesis* TFIC sp 03
s *Exithius cariosus* (Erichson, 1842)
a + *Exithius* sp TMAG_F122864
am + Leptopiini gen nr *Enchymus* sp TMAG_F122746
m + Leptopiini gen nr *Uroleptops* sp TMAG_F139310
a *Mandalotus* sp TMAG_F121400
s *Merimnetes australis* (Boisduval, 1835)
a *Merimnetes* ZIMMERMAN sp nov
s *Methypora postica* Pascoe, 1865
s *Ophrythyreocis cyclothyreus* (Lea, 1913)
s *Parorthorhinus lepidotus* (Erichson, 1842)
s *Pentamimus* sp TMAG_F73610
s *Poropterus antiquus* (Erichson, 1842)
s +*Poropterus* sp TMAG_F121146
m *Pseudometyrus vicarius* Lea, 1910
a *Roptoperus tasmaniensis* Lea, 1908
a *Scotasmus* unplaced
am *Storeus albosignatus* (Blackburn, 1890)
s *Tapinocis corticalis* Lea, 1913

Dermestidae
- ms *Trogoderma* sp TMAG_F100945
- am *Trogoderma* sp TMAG_F127635
- s *Trogoderma* sp TMAG_F131161

Dytiscidae
- a *Allodessus bistrigatus* (Clark, 1862)
- a *Antiporus femoralis* (Boheman, 1858)
- a *Limbodessus* unplaced
- a *Sternopriscus multimaculatus* (Clark, 1862)
- a *Sternopriscus weckwerthi* Hendrich & Watts, 2004

Elateridae
- s *Acroniopus granulatipennis* (Lea, 1908)
- a *Agrypnus* TFIC sp 02
- m *Crepidomenus decoratus* Erichson, 1842
- ams *Enischnelater specularis* (Candèze, 1889)
- s *Parablax nunden* Calder, 1986
- s + *Parablax* sp TMAG_F123004

Eucnemidae
- s Eucnemidae unplaced sp TMAG_F123006

Histeridae
- s *Teretrius sorellensis* Blackburn, 1903

Latridiidae
- ams *Cartodere nodifer* (Westwood, 1839)
- ams *Cortinicara* unplaced
- a Latridiidae unplaced sp TMAG_F122896
- m Latridiidae unplaced sp TMAG_F123424

Leiodidae
- s *Nargomorphus globulus* Jeannel, 1936
- s *Neopelatops* TFIC sp 01

Lucanidae
- a *Lissotes obtusatus* (Westwood, 1838)

Lycidae
- s *Porrostoma atratus* (Fabricius, 1801)
- ams *Porrostoma rhipidium* (W.S. Macleay, 1826)
- s *Xylobanus simplicicornis* (Lea, 1909)

Melandryidae
- a *Callidircaea venusta* (Champion, 1895)
- s *Ctenoplectron agile* Champion, 1895
- s *Orchesia minuta* Lea, 1908
- s *Orchesia* TFIC sp 22

Melyridae
- s *Hypattalus exilis* Lea, 1909
- m *Hypattalus montanus* Lea, 1909

Mordellidae
- s *Mordella* TFIC sp 01

Mycetophagidae
- s *Litargops intricatus* (Blackburn, 1891)

Mycteridae
- m *Trichosalpingus fumatus* (Champion, 1895)
- a *Trichosalpingus lateralis* Lea, 1895
- m *Trichosalpingus* sp TMAG_F123416

Nitidulidae
- s *Thalycrodes pulchrum* Blackburn, 1891

Oedemeridae
- ams *Asclera sublineata* (Waterhouse, 1877)
- as *Pseudolycus haemorrhoidalis* (Fabricius, 1801)

Phalacridae
- s *Litochrus* TFIC sp 01
- s Phalacridae unplaced sp TMAG_F115902

Ptinidae
- s *Deltocryptus* sp TMAG_F121141
- a *Dryophilodes minor* Lea, 1924
- s *Dryophilodes* TFIC sp 04
- s *Hadrobregmus areolicolle* (Lea, 1924)
- s *Ptinus exulans* Erichson, 1842

Pyrochroidae
- as *Temnopalpus bicolor* Blackburn, 1888

Salpingidae
- s *Neosalpingus hybridus* (Erichson, 1842)

Scarabaeidae
- am i *Aphodius fimetarius* (Linnaeus, 1758)
- s *Heteronyx pilosellus* Blanchard, 1850
- m *Podotenus* sp TMAG_F121774
- ms *Telura vitticollis* Erichson, 1842

Scirtidae
- a *Copiacyphon uncatus* (Watts, 2007)
- a *Copiacyphon variabilis* (Armstrong, 1953)
- ms *Macrodascillus insolitus* (Watts, 2010)
- a *Nothocyphon lanceolatus* Zwick, 2015
- as *Perplexacara latusmandibulara* (Watts, 2010)
- a *Pictacara montana* (Lea, 1919)
- a *Pictacara tasmanica* (Blackburn, 1892)

Scraptiidae
- ams *Scraptia laticollis* Champion, 1895
- s *Scraptia ocularis* Lea, 1920

Silphidae
- a *Ptomaphila lacrymosa* (Schreibers, 1802)

Staphylinidae
- ams Aleocharinae unplaced sp TMAG_F122792
- am Aleocharinae unplaced sp TMAG_F22496
- m *Coproporus* TFIC sp 03
- s *Myrmecocephalus fauveli* Solsky, 1868)
- s *Quediomimus hybridus* (Erichson, 1840)
- s *Quedius baldiensis* Blackburn, 1891
- as Scydmaeninae unplaced
- s *Sepedophilus* sp TMAG_F103193
- m *Zyras* TFIC sp 03

Tenebrionidae
- a *Adelium* sp TMAG_F122419
- a *Coripera deplanata* (Boisduval, 1835)
- s *Pachycoelia sulcicollis* Boisduval, 1835

Throscidae
- s *Aulonothroscus elongatus* (Bonvouloir, 1859)

Ulodidae
- m *Meryx aequalis* Blackburn, 1891

Zopheridae
- s *Cotulades leucospila* (Hope, 1843)
- s *Docalis funerosa* (Hope, 1845)

COLLEMOBOLA (SPRINGTAILS)

Katiannidae
- m Katiannidae unplaced

DERMAPTERA (EARWIGS)

Anisolabididae
- a *Gonolabis tasmanica* (Bormans, 1880)

Spongiphoridae
- s *Nesogaster ruficeps* (Erichson, 1842)

DIPTERA (TRUE FLIES)

Anisopodidae
- s *Sylvicola dubius* (Macquart, 1850)
- s *Sylvicola funebris* (Fuller, 1935)

Asilidae
- m *Cerdistus flavicinctus* (White, 1914)
- a *Cerdistus luctificus* (Walker, 1851)
- s *Daptolestes bronteflavus* Robinson & Yeates, 2020

Athericidae
- a *Dasyomma maculipenne* Hardy, 1920

Austroleptidae
- a *Austroleptis multimaculata* Hardy, 1920
- ms *Austroleptis rhyphoides* Hardy, 1920

Bibionidae
- as *Dilophus* unplaced
- s *Plecia dimidiata* Macquart, 1846

Bombyliidae
- m *Sisyromyia aurata* (Walker, 1849)

Calliphoridae
- a *Calliphora hilli* Patton, 1925
- m *Calliphora stygia* (Fabricius, 1782)

Chironomidae
- m Chironomidae unplaced sp TMAG_F105529
- a Chironomidae unplaced sp TMAG_F121803
- a Chironomidae unplaced sp TMAG_F123441

Dolichopodidae
- am *Chrysotimus* sp TMAG_F121337
- ms *Diaphorus* sp TMAG_F123200
- a *Diaphorus* sp TMAG_F97448

Drosophilidae
- ms Drosophilidae unplaced sp TMAG_F122988

Empididae
- a Empididae unplaced sp TMAG_F121846
- a Empididae unplaced sp TMAG_F123473
- a *Empis maculosa* Daugeron & Plant, 2009
- a *Empis* sp TMAG_F121333
- m *Empis* sp TMAG_F123137
- ams *Empis* sp TMAG_F123237
- a Hemerodromiinae unplaced sp TMAG_F121804
- a *Hilarempis* sp TMAG_F122520
- s *Hilarempis* sp TMAG_F123254
- m Hilarini gen nr *Hilarempis* sp TMAG_F122307
- a Hilarini gen nr *Hilarempis* sp TMAG_F122349
- a *Sphicosa* sp TMAG_F122249

Ephydridae
- a *Hydrellia victoria* Cresson, 1932
- a *Nostima duoseta* Cresson, 1943
- a *Scatella* unplaced

Helosciomyzidae
- m + *Eurotocus* sp TMAG_F122966

Heteromyzidae
- a *Austroleria extensa* McAlpine, 1967
- m *Diplogeomyza* cf *conformis* McAlpine, 1967
- m *Diplogeomyza diaphora* Hendel, 1917
- s *Diplogeomyza maculipennis* (Malloch, 1926)
- am *Leriopsis* sp TMAG_F100274
- s *Tapeigaster brunneifrons* Malloch, 1927
- a *Tapeigaster nigricornis* (Macquart, 1851)
- ms *Trixoleria maculata* McAlpine, 1967

Hybotidae
- am *Hoplopeza pulcherrima* (Bezzi, 1904)
- ams *Hoplopeza* sp TMAG_F123242
- a Ocydromiinae unplaced sp TMAG_F122906

Keroplatidae
- s Keroplatidae unplaced sp TMAG_F113965
- m Keroplatidae unplaced sp TMAG_F122978
- s Keroplatidae unplaced sp TMAG_F123224
- am Keroplatidae unplaced sp TMAG_F47589

Lauxaniidae
- m *Ceratolauxania* sp TMAG_F98212
- a Lauxaniidae unplaced sp TMAG_F121785
- ms Lauxaniidae unplaced sp TMAG_F128648
- am *Poecilohetaerus aquilus* Schneider, 1991
- s *Rhagadolyra magnicornis* (Malloch, 1926)
- ams *Sapromyza magnifica* Malloch, 1926
- m *Sapromyza mallochiana* Evenhuis & Okadome, 1989
- ams *Sapromyza metallica* Walker, 1853
- m *Trypetisoma digitatum* Kim, 1994

Limoniidae
- a *Gynoplistia* sp TMAG_F96875

Muscidae
- a Muscidae unplaced sp TMAG_F121825
- a Muscidae unplaced sp TMAG_F41370

Mycetophilidae
- a Mycetophilidae unplaced sp TMAG_F121838

Pelecorhynchidae
- am *Pelecorhynchus albolineatus* Hardy, 1918

Piophilidae
- a *Piophilosoma norrisi* (Paramonov, 1954)

Platystomatidae
- as *Rivellia* sp TMAG_F121455
- m *Rivellia* sp TMAG_F122990

Rhagionidae
- a *Atherimorpha* cf *corpulenta* Paramonov, 1962
- ams *Atherimorpha occidens* Hardy, 1927
- s *Atherimorpha* sp nr *montana* Hardy, 1927
- a *Atherimorpha* sp TMAG_F122233
- a *Chrysopilus basifasciatus* Paramonov, 1962

Sarcophagidae
- m i *Oxysarcodexia varia* (Walker, 1836)

Sciomyzidae
- am *Dichetophora australis* (Walker, 1853)

Stratiomyidae
- ms *Antissella parvidentata* (Macquart, 1850)
- m *Australoactina costata* (White, 1914)
- ms *Boreoides tasmaniensis* Bezzi, 1922
- m Chiromyzinae unplaced sp TMAG_F31516
- s *Damaromyia whitei* (Hardy, 1920)
- m *Inopus* sp TMAG_F121819
- m *Odontomyia carinifacies* Macquart, 1850

Syrphidae
- m *Austalis pulchella* (Macquart, 1846)
- m *Eristalis tenax* (Linnaeus, 1758)
- as *Eumerus argyrogaster* Ferguson, 1926
- ams *Melangyna viridiceps* (Macquart, 1847)
- a *Oligeriops chalybeus* (Ferguson, 1926)
- ms *Psilota* sp TMAG_F96866
- m *Xanthandrus agrolas* (Walker, 1849)
- s *Xanthandrus* YOUNG sp 88-7
- am *Xanthandrus* YOUNG sp *ruficornis*

Tabanidae
- am *Dasybasis neolatifrons* (Ferguson & Hill, 1922)
- a *Dasybasis* sp TMAG_F46932
- m *Scaptia auriflua* (Donovan, 1805)
- ams *Scaptia jacksonii* (Macquart, 1837)

Tachinidae
- ams *Senostoma* unplaced
- m Tachinidae unplaced sp TMAG_F57514
- a *Trigonospila* unplaced

Tephritidae
- a *Austrotephritis bushi* (Hardy & Drew, 1996)
- a *Spathulina acroleuca* (Schiner, 1868)
- a *Sphenella ruficeps* (Macquart, 1851)
- m Tephritidae unplaced sp TMAG_F125990

Therevidae
- m *Actenomeros corniculaticaudus* Winterton & Irwin, 1999
- s *Anabarhynchus lanatus* Lyneborg, 2001
- ms *Anabarhynchus montanus* White, 1916
- m *Anabarhynchus whitei* Lyneborg, 2001

Tipulidae
- am *Acracantha sydneyensis* Skuse, 1890
- a *Ischnotoma rubroabdominalis* Alexander, 1922

HEMIPTERA (TRUE BUGS)

Acanthosomatidae
- a *Amphaces* cf *elongata* Distant, 1910
- a *Anischys lundbecki* (Jensen-Haarup, 1928)
- a *Eupolemus picturatus* Distant, 1910

Achilidae
- s Plectoderini MOIR genus 5 MOIR sp 85
- s Plectoderini MOIR genus 6 MOIR sp 87
- as Plectoderini MOIR genus 6 MOIR sp 88
- as *Dipsiathus obscurifrons* Emeljanov, 2005
- s *Parabunda tasmanica* Emeljanov, 2005

Aphalaridae
m *Anoeconeossa* sp TMAG_F97427
am *Creiis lituratus* (Froggatt, 1900)
m *Ctenarytaina* sp TMAG_F122309
s *Phellopsylla* sp TMAG_F123264
m Spondyliaspidinae cf *Australopsylla* sp TMAG_F122979
m Spondyliaspidinae cf *Blepharocosta* sp TMAG_F123420
Aphididae
m *Myzus* cf *persicae* (Sulzer, 1776)
Artheneidae
a *Dilompus woodwardi* Malipatil, 1988
Ceratocombidae
s *Ceratocombus australiensis* Gross, 1950
Cercopidae
ms *Anyllis leiala* Kirkaldy, 1906
a *Bathyllus albicinctus* (Erichson, 1842)
Cicadellidae
a *Arawa novella* Metcalf, 1968)
a *Austroagalloides rosea* Evans, 1936
ms *Batracomorphus elegans* (Evans, 1936)
as Cicadellidae unplaced sp TMAG_F101390
m Cicadellidae unplaced sp TMAG_F106140
a Cicadellidae unplaced sp TMAG_F123439
m Cicadellidae unplaced sp TMAG_F76645
s *Diemoides smithtoniensis* Evans, 1938
a *Neotartessus flavipes* (Spångberg, 1878)
ms *Putoniessa dorsalis* (Walker, 1851)
ms *Rhotidoides montana* Evans, 1937
a *Rosopaella crofta* Webb, 1983
m Tartessinae unplaced sp TMAG_F47837
s *Tolasella* sp TMAG_F96921
Cicadidae
a *Diemeniana hirsuta* (Goding & Froggatt, 1904)
Cixiidae
m *Aka dobsonensis* Löcker, 2015
ams *Chidaea armidalensis* Löcker & Holzinger, 2019
a Cixiinae unplaced sp TMAG_F142311
Coreidae
s *Gelonus tasmanicus* (Le Guillou, 1841)
Corixidae
a *Sigara* unplaced
Cryptorhamphidae
a *Cryptorhamphus orbus* Stål, 1860
Cydnidae
m *Macroscytus* sp TMAG_F6477
Idiostolidae
m *Monteithocoris hirsutus* Woodward, 1968
Lygaeidae
a *Nysius* unplaced
Micronectidae
a *Micronecta robusta* Hale, 1922
Miridae
a *Coridromius* sp TMAG_F57794
a Miridae unplaced sp TMAG_F122289
a Miridae unplaced sp TMAG_F122633
as Miridae unplaced sp TMAG_F57119
am Miridae unplaced sp TMAG_F57339
ams *Niastama punctaticollis* Reuter, 1904
ams *Pseudopantilius australis* (Walker, 1873)
Notonectidae
a *Anisops thienemanni* Lundblad, 1933
Pentatomidae
s *Notius depressus* Dallas, 1851
ms *Tinganina dimorpha* Bergroth, 1909
Reduviidae
s *Nebriscus pupus* Bergroth, 1895
Rhyparochromidae
as *Botocudo ornatulus* (Bergroth, 1895)
ams *Brentiscerus putoni* (White, 1878)
a *Euander torquatus* (Erichson, 1842)
a *Remaudiereana inornata* (Walker, 1872)
a Rhyparochromidae unplaced sp TMAG_F122291
a Rhyparochromidae unplaced sp TMAG_F122852
a *Telocoris* sp TMAG_F97797
a *Udeocoris nigroaeneus* (Erichson, 1842)
Schizopteridae
ms Schizopteridae unplaced sp TMAG_F123187
Tettigarctidae
m *Tettigarcta tomentosa* White, 1845

HYMENOPTERA (WASPS, BEES & ANTS)
Apidae
a i *Bombus terrestris audax* (Linnaeus, 1758)
m *Exoneura* unplaced
Bethylidae
a *Eupsenella* unplaced
Braconidae
m Braconinae unplaced sp TMAG_F123405
a Braconidae unplaced sp TMAG_F122775
a *Doryctes* unplaced
s Rogadinae unplaced sp TMAG_F94569
Chalcididae
a Chalcididae unplaced sp TMAG_F122763
Colletidae
am *Euhesma* sp TMAG_F123453
m *Leioproctus* sp TMAG_F3995
Crabronidae
m *Acanthostethus tasmanicus* (Turner, 1915)
m *Pison rufipes* Shuckard, 1838
Evaniidae
a *Szepligetiella* sp TMAG_F100790
Formicidae
s *Camponotus hartogi* Forel, 1902
a *Iridomyrmex alpinus* Heterick & Shattuck, 2011
m *Myrmecia pilosula* Smith, 1858
s *Myrmecorhynchus carteri* Clark, 1934
Halictidae
am *Lasioglossum* unplaced
Ichneumonidae
a Banchinae unplaced sp TMAG_F122751
m Cryptinae unplaced sp TMAG_F112402
a *Heteropelma* unplaced
am *Ichneumon promissorius* (Erichson, 1842)
a Labeninae unplaced sp TMAG_F9885
a *Labium montivagum* Turner & Waterston, 1920
s *Poecilocryptus nigromaculatus* Cameron, 1901
Mutillidae
m *Ephutomorpha* sp TMAG_F127570
Pompilidae
m *Epipompilus bushi* Evans, 1972
m *Epipompilus gilesi* (Turner, 1910)
m *Epipompilus* sp TMAG_F123150
ams *Epipompilus tasmanicus* Evans, 1962
s *Epipompilus turneri* Evans, 1962
m Pompilidae unplaced sp TMAG_F123152
a Pompilinae unplaced sp TMAG_F115028
am *Sphictostethus aliciae* (Turner, 1914)
s *Sphictostethus geevestoni* Krogmann & Austin, 2011
Pteromalidae
m Pteromalidae unplaced
Tiphiidae
s *Tachynomyia abdominalis* (Guérin-Méneville, 1842)
Vespidae
m i *Vespula germanica* (Fabricius, 1793)

LEPIDOPTERA (MOTHS & BUTTERFLIES)

Anthelidae

s *Anthela acuta* (Walker, 1855)
m *Anthela nicothoe* (Boisduval, 1832)

Crambidae

a Crambinae unplaced sp TMAG_F149387
am Crambidae unplaced sp TMAG_F118319
a *Eudonia cleodoralis* (Walker, 1859)
a *Musotima nitidalis* (Walker, 1866)
am *Scoparia plagiotis* Meyrick, 1887
am *Scoparia syntaracta* Meyrick, 1885

Depressariidae

m *Agriophara* sp TMAG_F149388
m *Agriophara* sp TMAG_F29992
m *Eutorna eurygramma* Meyrick, 1906

Erebidae

s *Ardices glatignyi* (Le Guillou, 1841)
m *Artigisa lignicolaria* (Walker, 1866)
m *Chiriphe sicciodes* (Hampson, 1914)
m *Halone sobria* Walker, 1854
m *Philenora omophanes* (Meyrick, 1886)
am *Thallarcha isophragma* (Meyrick, 1886)
am *Thermeola tasmanica* Hampson, 1900

Geometridae

m *Acodia orina* (Turner, 1926)
am *Amelora acromegala* McQuillan, 1996
a *Amelora oritropha* Turner, 1919
m *Amelora sparsularia* (Guenée, 1857)
m *Aponotoreas cheimatobiata* (Guenée, 1857)
m *Archephanes zalosema* Turner, 1926
m *Authaemon stenonipha* Turner, 1919
am *Chloroclystis filata* (Guenée, 1858)
a *Chlorocoma cadmaria (Guenée, 1857)*
m *Chrysolarentia epicteta* (Turner, 1908)
m *Chrysolarentia heteroleuca* (Meyrick, 1891)
m *Chrysolarentia interruptata* (Guenée, 1858)
m *Chrysolarentia leucozona* (Meyrick, 1891)
a *Chrysolarentia photographica* (Turner, 1939)
am *Chrysolarentia polycarpa* (Meyrick, 1891)
a *Chrysolarentia psarodes* (Turner, 1904)
a *Chrysolarentia subrectaria* (Guenée, 1858)
s *Circopetes obtusata* (Walker, 1860)
ms *Cyneoterpna alpina* Goldfinch, 1929
m *Dolabrossa suffusa* Turner, 1926
a *Epyaxa centroneura* (Meyrick, 1891)
a *Euloxia leucochorda* (Meyrick, 1888)
m *Furcatrox australis* (Rosenstock, 1885)
m Geometrinae unplaced *melanoglypta* Lower, 1905
m *Horisme mortuata* (Guenée, 1857)
m Hydriomenini unplaced *severata* (Guenée, 1857)
s *Hypobapta percomptaria* (Guenée, 1857)
ms *Melitulias oriadelpha* Turner, 1926
am *Microdes diplodonta* Turner, 1904
a *Microdes leptobrya* Turner, 1939
ams + *Microdes oriochares* Turner, 1922
am *Microdes villosata* Guenée, 1857
m *Mnesampela heliochrysa* (Lower, 1893)
m *Mnesampela privata* (Guenée, 1857)
m *Nearcha curtaria* (Guenée, 1857)
am *Palleopa innotata* Walker, 1866
am *Paralaea chionopasta* McQuillan, Young & Richardson, 2001
a *Pasiphilodes testulata* (Guenée, 1857)
ms *Plesanemma altafucata* McQuillan, 1984
m *Poecilasthena euphylla* (Meyrick, 1891)
a *Poecilasthena panapala* Turner, 1922
am *Poecilasthena pulchraria* (Doubleday, 1843)
m *Psilosticha attacta* (Walker, 1860)
m *Scioglyptis* sp CB01
m *Scopula liotis* (Meyrick, 1888)
a *Scopula optivata* (Walker, 1861)
m *Scopula perlata* (Walker, 1861)
m *Taxeotis intextata* (Guenée, 1857)
ams *Xanthorhoe anaspila* Meyrick, 1891
am *Xanthorhoe anthracinata* (Guenée, 1857)
am *Xanthorhoe strumosata* (Guenée, 1857)

Hepialidae

m *Abantiades latipennis* Tindale, 1932

Lasiocampidae

m *Pararguda nasuta* (Lewin, 1805)
s *Pararguda rufescens* (Walker, 1855)
m *Crocanthes glycina* Meyrick, 1904

Lycaenidae

am *Neolucia hobartensis hobartensis* (Miskin, 1890)

Lyonetiidae

m Bedelliinae unplaced
m Lyonetiinae unplaced

Noctuidae

am *Agrotis infusa* (Boisduval, 1832)
ams *Cirphis ebriosa* (Guenée, 1857)
a *Dasygaster padockina* (Le Guillou, 1841)
m *Dasygaster pammacha* Guenée, 1852
m *Dasygaster* sp TMAG_F146972
a *Diarsia intermixta* (Guenée, 1857)
m *Ectopatria* unplaced
am Hadenini unplaced species inquirenda *epipolia*
m Hadenini unplaced species inquirenda *ligniplena*
m *Helicoverpa punctigera* (Wallengren, 1860)
am *Leucania* ANIC sp 02
m *Neumichtis iorrhoa* (Meyrick, 1902)
m *Neumichtis nigerrima* (Guenée, 1857)
am *Neumichtis sepultrix* (Guenée, 1857)
am *Neumichtis* sp TMAG_F029835
am *Neumichtis* sp TMAG_F141335
am *Persectania ewingii* (Westwood, 1839)
a *Proteuxoa atra* (Guenée, 1852)
am *Proteuxoa hydraecioides* (Guenée, 1852)
am *Proteuxoa sanguinipuncta* (Guenée, 1857)
a *Proteuxoa* sp TMAG_F141362
m *Proteuxoa* sp TMAG_F141376
am *Proteuxoa* sp TMAG_F141378

Nolidae

m *Nola* ANIC sp 03

Notodontidae

m *Aglaosoma periblepta* (Turner, 1922)
ms *Gallaba eugraphes* Turner, 1922
am *Hobartina amblyiodes* (Turner, 1931)

Nymphalidae

am *Heteronympha penelope diemeni* Waterhouse, 1937
a *Oreixenica lathoniella lathoniella* (Westwood, 1851)

Oecophoridae

am *Cosmaresta charaxias* (Meyrick, 1889)
m *Oxythecta nephelonota* Meyrick, 1885
a *Oxythecta* unplaced sp TMAG_F154208
s *Oxythecta* unplaced sp TMAG_F154209
am *Palimmeces hemiphanes* (Meyrick, 1883)
m *Philobota* BB SW TAS sp 04
m *Thema endesma* (Meyrick, 1884)

Pieridae

a i *Pieris rapae* (Linnaeus, 1758)

Plutellidae

a i *Plutella xylostella* (Linnaeus, 1758)

Pyralidae

ams *Mimaglossa crypserythra* (Turner, 1904)
m *Stericta marmorea* (Warren, 1891)

Tineidae

m *Monopis ethelella* (Newman, 1856)

Tortricidae
- a *Acropolitis* ANIC sp 06
- m *Acropolitis ptychosema* Turner, 1927
- m Bactrini unplaced sp TMAG_F047715
- a *Constrictana constrictana* (Walker, 1866)
- m *Holocola* ANIC sp 66
- a *Meritastis lythrodana* (Meyrick, 1881)
- s *Rupicolana crotala* (Meyrick, 1910)
- a *Technitis technica* (Turner, 1939)

Xyloryctidae
- m *Scieropepla serina* Meyrick, 1890

MECOPTERA (SCORPIONFLIES & ALLIES)
Nannochoristidae
- a *Nannochorista maculipennis* Tillyard, 1917

NEUROPTERA (LACEWINGS)
Chrysopidae
- a *Apertochrysa edwardsi* (Banks, 1940)

Hemerobiidae
- ams *Micromus tasmaniae* (Walker, 1860)
- am *Notherobius nothofagi* New, 1988

ORTHOPTERA (GRASSHOPPERS & CRICKETS)
Acrididae
- a *Russalpia albertisi* (Bolívar, 1898)
- a *Tasmanalpina clavata* Key, 1991
- a *Tasmaniacris tasmaniensis* (Bolívar, 1898)

Gryllacrididae
- a *Kinemania ambulans* (Erichson, 1842)

Pyrgomorphidae
- m *Monistria concinna* (Walker, 1871)

Tetrigidae
- a *Paratettix argillaceus* (Erichson, 1842)

Tettigoniidae
- m *Acripeza reticulata* Guérin-Méneville, 1838

Trigonidiidae
- a *Bobilla* unplaced

PLECOPTERA (STONEFLIES)
Eustheniidae
- a *Eusthenia spectabilis* Gray, 1832

THYSANOPTERA (THRIPS)
Phlaeothripidae
- am *Idolothrips spectrum* Haliday, 1852

TRICHOPTERA (CADDISFLIES)
Plectrotarsidae
- a *Plectrotarsus tasmanicus* Mosely, 1936